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Listed are guidelines for the steps in the development of a flexible long-range senior science curriculum. The program is separated into biology, chemistry, and physics, and a course outline is given for each. These outlines are not committed to any one approach, but draw on the many curriculum improvement projects and other sources. The emphasis is on laboratory experiences which emphasize principles, concepts, the nature of scientific investigation, and the undertainities inherent in scientific work. The outline is suggestive rather than prescriptive and is designed to allow the teacher flexibility in designing his own program. A science curriculum flow chart shows the proposed sequence of courses for grades 7-12, with suggestions for possible points of termination for various students. Basic, general, and accelerated programs are identified. (GR)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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SENIOR HIGH SCHOOL SCIENCE CURRICULUM

GUIDE LINES

" A BEGINNING EFFORT TO PRODUCE THE BEST POSSIBLE SCIENCE CURRICULUM FOR STUDENTS IN DUVAL COUNTY."

SUMMER 1966

ED023604

NOTE: This book has been produced so that all personnel can be a part of science curriculum development.

SE 005 420

STUDY
CRITICIZE
IMPROVE
USE
IT

Duval County Board of Public Instruction

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The age in which we live, where knowledge in all fields is finding no boundaries, has forced all educational institutions to take a closer view of their instructional programs and determine how well they are preparing students for a purposeful place in an expanding world. Duval County Schools have been and are engaged in many programs which will improve and strengthen all areas of instruction.

Science is one of the fields which has taken giant strides in recent years. Society is making changes to better align itself with the many technological advances encompassing all walks in life.

To help prepare our students for a changing world, science curriculum committees have made studies and prepared these guides that will help you improve your science instruction on a continuing basis. The guides are required by accreditation standards. Their effectiveness will be determined by the teachers who use them conscientiously.

Ish Brant

Ish Brant
Superintendent

The Duval County Public Schools are in the process of providing an educational program for our students that will be second to none. All phases of the program are being evaluated and improved and, as a part of this improvement, curriculum studies have been advanced and expanded in most areas of the school program with the development and revision of teaching guides.

The science curriculum guide for the Junior High School which has been in use during the past year has been revised and, for the first time, a Senior High School curriculum study has been made.

It is my desire that all teachers of science will use these guides where applicable and will continually offer recommendations for their improvement.

Jas. C. Hilliard

James C. Hilliard
Assistant Superintendent
for Instruction

As the studies in science become more voluminous and the need for men and women with understanding in the sciences increases, we who are responsible for the education of our students must keep pace with what is needed and be constantly aware of the content of our science program and its ability to meet these needs.

For this reason, science curriculum studies are essential for focusing our attention on the science program in the Duval County Public Schools and for observing carefully what is required to always improve our science instruction.

I request, therefore, that you give careful consideration to what has been produced by the efforts of the science curriculum committee and then put it to use.

My thanks to the curriculum committee which has produced these studies for our use.

Robert H Liston

Robert H. Liston
Supervisor of Science

INTRODUCTION

The science curriculum committee has prepared these guidelines as initial and additional steps in the development of a flexible and long-range science curriculum. Science education is in a process of metamorphosis; we do not know, nor can we completely know, what the outcome will be. Our objective is to produce a curriculum that is so constructed that it can be continually revised and enriched as it is found that it is not serving the needs of the student.

The program should consider the interests, abilitites, and socio-economic background of the student. It must work for each student individually as well as for the total group. It must engender all aspects of providing purposeful scientific knowledge, allowing for inquiry and discovery, and, above all, developing critical thinking.

We must remember, however, that no curriculum guideline can be effective without the complete cooperation of all schools and all teachers by using it and offering constructive criticism for improvement. We want all teachers and administrators involved in curriculum building.

The committee, therefore, requests that you study what has been suggested as a guideline, inject into your curriculum the concepts set forth, and make constructive modifications and revisions. The guidelines will be sent to the curriculum committee later and questionnaires will be sent to every teacher for additional informational data.

PURPOSES OF THE COMMITTEE

1. To provide direction for a science curriculum study and bring forth recommendations for inclusions, revisions, and exclusions of the present plan stemming from group and individual research in areas vital to the ongoing of the science program for Duval County.
2. To provide a basis for continuing re-evaluation and revision of the science curriculum so as to enable it to keep pace with rapid scientific and technological changes in our space-age science.
3. To bring the present science curriculum into focus, so as to reflect the standards set forth for accreditation requirements.
4. To take advantage of prior studies and revisions of various science curricula conducted by school systems comparable to Duval County and incorporate their salient aspects into our own program.
5. To study requirements for reference and equipment facilities, so as to fulfill basic needs within the schools.
6. To provide a basis for school-community liaison designed to benefit the student through specification of certain skills or bodies of knowledge needed by the student to take his place in society.

7. To set forth goals and standards which will enable students of varying abilities to achieve within their capabilities. This could be accomplished through a sequential program of science studies designed to meet individual needs.
8. To develop objective, orderly modes of problem solving that will challenge the student and will enable the student to recognize a need for following similar procedures in solving other problems of life.
9. To institute procedures that will promote the development of skills relevant to science that would contribute the most to the student's personal life and to an understanding of himself, his environment, and to the execution of his responsibility as a citizen.
10. To develop a curriculum guide for each science discipline beginning with life science, physical science, earth science, biology, chemistry, physics, and extensions of these.

Philosophy

A science education program should be geared to the needs of society. Our scientific age increasingly requires more proficiency in science educational processes to produce a flexible, adaptable and scientifically literate citizenry. The teacher has the function of inspiring, guiding, reaffirming, reinforcing and encouraging the student to be more curious and to think in depth so that he can become such a citizen. This program then must also be flexible enough to adapt itself to constant change.

The school science program must be integrated with the other programs where possible; but science, by design, is a way of thinking. Eventually our study of science interflows with the whole of human thought and activity, therefore, the development of the scientific way of thinking in every young person is a solemn obligation of our schools.

Achievement of this program by the teacher requires that the following conditions be provided:

1. A well prepared staff
2. A good working environment
3. Limited class size
4. Time for teacher preparation and evaluation
5. Equipment and facilities

The prime responsibility of science teachers continues to be the development of individuals into citizens who can succeed in a science-oriented society.

PROPOSED OBJECTIVES FOR SCIENCE TEACHING

The science curriculum committee, through much research and consideration, has tried to consolidate the most important objectives for science teaching into the following four brief statements. Under each one are questions to help clarify the meaning implied in these four statements.

1. To develop an awareness of the environment, and the recreational, health, and material benefits derived from it through an understanding of the scientific processes.
    a. Do you constantly remind students to be alert and aware of the scientific nature of the everyday activities going on around them?
    b. Do they understand the place science has in providing them with leisure time, improved health, and the many conveniences of their daily lives?
    c. Are they acquiring a useful command of science concepts and principles?
2. To use research and experimentation as a means by which the student may learn orderly and independent thinking.
    a. Do you encourage and require the use of reference materials?

   b. Do you provide students with the exciting experience of "discovery" through constant use of experimentation?

   c. Do you require neat and organized data taking, notebooks, assignments, research papers, etc.?

   d. Do you "tell" them or do you let them "tell" you?

3. To create interest in science and develop learning modes that will lead either to advanced scientific endeavors or to an application of these to any vocation.

   a. Are you enthusiastic about what you teach?

   b. Do you encourage different approaches to the solving of problems and the follow up of "hunches" or reasonable guesses?

   c. Do you encourage students to enter the fields of science or relate application of scientific principles and learning modes to various occupations?

4. To instill tangible and aesthetic values in the student as a worthwhile individual in an enlightened society that has been implemented by past scientific achievements and promises of greather things to come.

   a. Do you habitually demonstrate respect, fairness, impartiality, honesty, moral character, etc?

   b. Do you try to make each student feel that he is important and that he has a contribution to offer to society?

c. Do you acquaint them with scientists of the past and present and with the contributions they have made to the world?

d. Do you exite students with discussing future scientific achievements?

EXPLANATION OF FLOW CHART

The flow chart has been developed to help plan for a more unified scope and sequence in science curriculum for Duval County. In the Junior High School the scope and sequence have been developed, and evaluation and revision are being done. The scope and sequence of the Junior and Senior High will be revised if necessary as the elementary program in science progresses. Science curriculum development must be K-12.

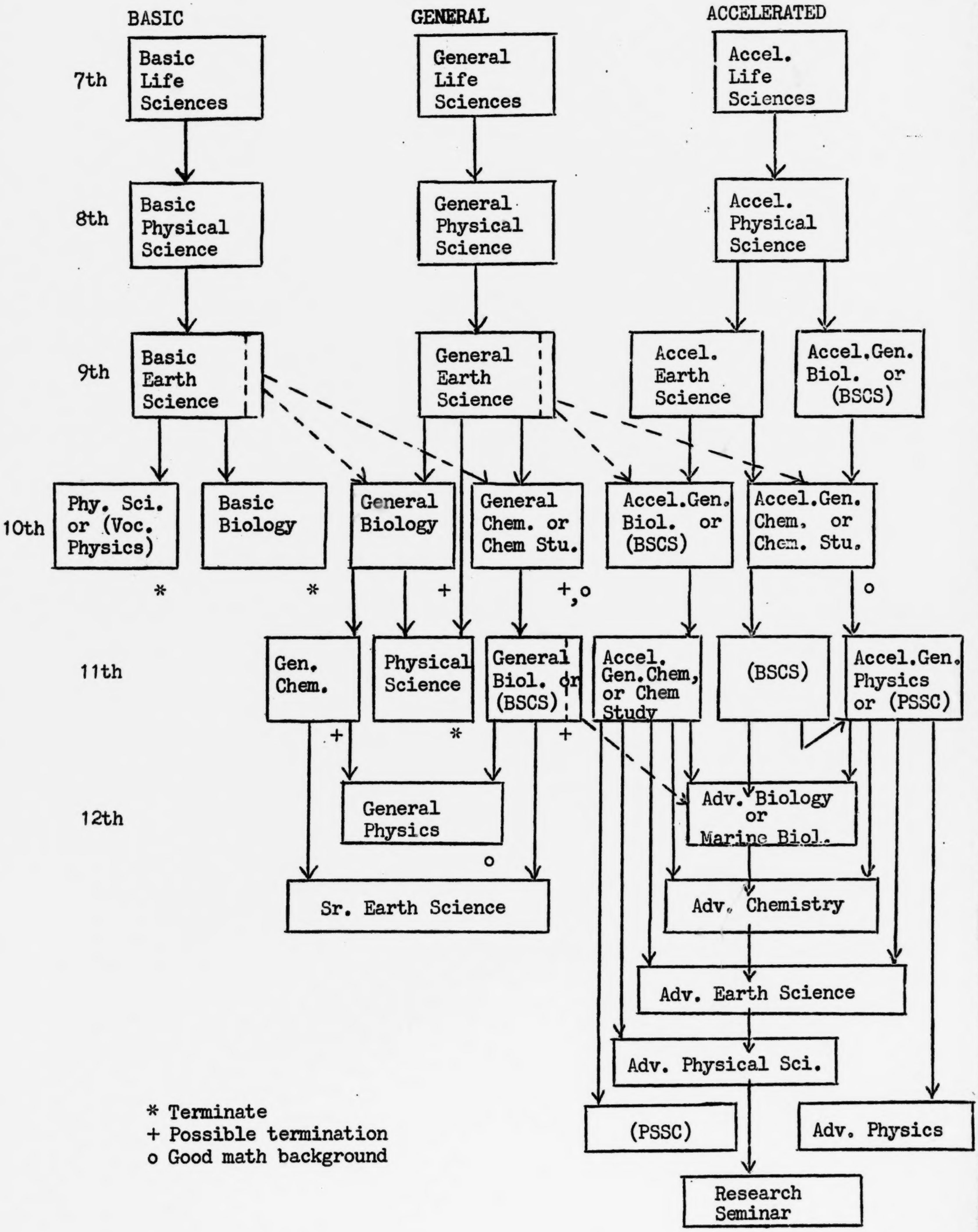
The chart indicates required accreditation ability levels and suggests a sequence for each level from 7 to 12. It should be definitely noted in the average and above-average levels that flexibility is suggested. Individual school and community requirements and facilities should determine what courses in biology, chemistry, or physics should be offered. A choice of advanced courses is suggested with the possiblility of a student taking two science courses in the same year _if_ he is capable.

It is suggested that cross-over can occur from one level to another but only at certain places and only when students show that they can succeed at a higher level.

It is our purpose to develop some unity in our curriculum, yet allow for varied individual approaches to the teaching of scientific concepts. Therefore, all accepted general or traditional courses, as well as all advanced courses, should be designed to meet the needs of the students representative of that school and community, but similar courses should contain basic concepts. This is to say that all courses in General Biology or Advanced Chemistry, for example, should contain basic concepts which are taught, with little exception, in the same, most logical sequence.

Several courses are shown for Senior High School which are only suggested possibilities. These are: Vocational Physics, Senior Earth Science, Marine Biology, Advanced Earth Science, Advanced Physical Science, and a Research Seminar.

SCIENCE CURRICULUM FLOW CHART


BASIC
GENERAL
ACCELERATED
7th
8th
9th
10th
11th
12th
Basic Life Sciences
General Life Sciences
Accel. Life Sciences
Basic Physical Science
General Physical Science
Accel. Physical Science
Basic Earth Science
General Earth Science
Accel. Earth Science
Accel.Gen. Biol. or (BSCS)
Phy. Sci. or (Voc. Physics)
Basic Biology
General Biology
General Chem. or Chem Stu.
Accel.Gen. Biol. or (BSCS)
Accel.Gen. Chem. or Chem. Stu.
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+,o
o
Gen. Chem.
Physical Science
General Biol. or (BSCS)
Accel. Gen.Chem, or Chem Study
(BSCS)
Accel.Gen. Physics or (PSSC)
+
*
+
General Physics
o
Sr. Earth Science
Adv. Biology or Marine Biol.
Adv. Chemistry
Adv. Earth Science
Adv. Physical Sci.
(PSSC)
Adv. Physics
Research Seminar
* Terminate
+ Possible termination
o Good math background

RECOMMENDATIONS

If our aim is to develop the best possible science curriculum for Duval County, we must have all science teachers and all administrators taking a part. Constant research, evaluation and communication must take place.

Therefore, we recommend the following:

1. Science curriculum studies continue throughout the year.
2. Committee personnel should be given either time from their daily work schedule or compensation for extra hours of work.
3. The committee should have a place to work where all work can be coordinated, K-12.

   Suggestion: One of the government buildings now owned by the school system be remodeled into a Science Curriculum Study Center.
4. Occasional meetings of all personnel involved in certain science disciplines should be held as directed by the assistant superintendent of education and the supervisor of science.

   Purpose: To evaluate, discuss, improve curriculum and to gather information.
5. Science Curriculum Committee

   Members: 5 teachers and 1 administrator from each area: Elementary,

   Junior High, and Senior High

   Science supervisor and helping teachers

   Meetings: Bi-monthly

   Hours: 4 hours minimum per meeting

   Sub-committees: Members of the teaching profession appointed by the curriculum committee.

Sub-committee work:

Committee #1:	Prepare a standard list of materials and equipment (minimum necessary) needed in each science discipline. Secure an inventory from every school. Equalize existing materials and equipment in schools. Determine what each school needs to meet minimum standards.
Committee #2:	Survey industrial needs and suggest curriculum revision to meet the desires of industry. Form a liason between science and the community.
Committee #3:	Develop good orderly modes of problem solving, design exciting and "discovery" type experiments for students to perform and organize workshops for teachers where these can be demonstrated.
Committee #4:	Keep informed and inform all personnel of the trends, new ideas, and studies occuring in other parts of the country, and evaluate new texts, films, etc.

6. All teachers involved in lab work must have sufficient time to set up labs.

   Schedules should provide for this.

7. Science Department Chairmen must be given time to plan and conduct in-service programs, evaluate curriculum and perform department duties.

8. If the department chairman is going to take on supervisory and administrative duties, his status should be raised by compensation.
9. Provide a "follow-up" program of science students after they have graduated. We are mainly involved in the processes of science learning, but we should know the product of our efforts in order to evaluate our teaching of these processes.
10. Curriculum planning and planning of plant facilities must coincide. Therefore, teachers should be involved (consulted) in planning rooms and facilities **before** they are constructed.
11. We recommend that each teacher be provided one teacher's edition of each of the texts listed in the bibliographies of our guides, plus the teacher's guide and 25 copies of each laboratory manual suggested.

GENERAL BIOLOGY

Purpose: To acquaint the student with the forms and functions of the living world so that he may find his place in it and to promote attitudes and skills that will be flexible enough to serve the student in any vocation and also prepare the way for future study.

Overall Objectives for General Biology:

1. To further acquaint students with fundamental biological principles.
2. To offer a course which may be terminal for some that will prepare them for everyday life with emphasis on human physiology, genetics, and applied biology.
3. To continually expose the student to nature, its forms and functions, in order to broaden his understanding of how to live in his environment.
4. To acquaint the student with fundamental principles and concepts necessary for future study, as well as, fostering constructive attitudes and habits concerning health, disease, plants, animals, heredity, and anatomy.
5. To increase the spirit of inquiry rather than just acceptance of facts.
6. To reflect the current state of biology and construct a defensible general education in biology at the high school level.

I. Introduction

A. Problem: Of what does the study of biology consist?

B. Objectives:

1. Further acquainting the student with the life sciences.
2. Further acquainting the student with the branches of biological science.
3. Re-emphasizing the scientific method of discovery.
4. More emphasis on good study habits, note-taking and reporting.
5. Using the laboratory as a place of discovery.
6. Becoming more aware of, and developing a better appreciation for, the importance of biology to daily life.
7. Providing a clearer insight to the nature of biological research.

C. Principles and Concepts:

1. Biology is related to other science fields.
2. Biology is studied in subdivisions, and the scientific method is made use of.
3. The study of biology helps the student appreciate the importance of biological knowledge in everyday life, present, past, and future.
4. The use of the scientific method improves the ability to make accurate observations and draw valid conclusions.

D. Content:

1. Relationship of biology to other fields
    a. Chemistry
    b. Physics, etc.
2. Principal subdivisions of biology according to organism
    a. Zoology
        (1) Protozoology
        (2) Entomology
        (3) Ornithology
        (4) Icthyology
        (5) Herpetology
        (6) Mammology
        (7) Anthropology
    b. Botany
        (1) Thallophyta
        (2) Bryophyta
        (3) Tracheophyta
3. Principal subdivisions of biology according to approach
    a. Genetics
    b. Physiology
    c. Taxonomy
    d. Evolution
    e. Biochemistry
    f. Embryology
    g. Ecology
    h. Paleontology
    i. Parasitology
    j. Morphology

(1) Anatomy

(2) Histology

(3) Cytology

4. The scientific method of thinking

E. Motivating Activities

1. Discuss the application of the scientific method by selected scientists in solving a particular problem.
2. Introduce the microscope.
3. Discuss various fields into which biology may lead.
4. Discuss present trends in biology.
5. Discuss the importance of biology to the general welfare of the community.

F. Experiments and/or Demonstrations

1. Parts of the microscope
2. Handling, storage and care of microscope
3. Correct use of the microscope
    a. Use of low power objective
    b. Use of high power objective

G. Enrichment Activities

1. Make observations of various things macroscopically and microscopically.
2. Discuss the relationship of the microscope to biological progress.
3. Demonstrate the use of stanins and dyes.

H. Teacher Aids:

1. Films:
    a. Microscope 10' B/W EJS YA

- b. Prehistoric Times World Before Man 11' B/W EJS cn
- c. Scientific Method 12' B/W JS BR
- d. Why Study Science 11' B/W JS MH
- e. Cell: Structural Unit of Life 10' B/W JS COR

II. Cells and Protoplasm

- A. Problem: What are cells and what do they do?
- B. Objectives:
  1. Further acquainting the student with the development of the cell theory.
  2. Learning how the cell functions as an integrated whole.
  3. Understanding how materials enter and leave the cell.
  4. Gaining a knowledge of cellular chemistry and physiology.
  5. Becoming acquainted with the characteristics of living things.
  6. Showing the organization and specialization of cells.
  7. Gaining a knowledge of the organic and inorganic constituents of protoplasm.
  8. Learning the position of theories and hypotheses in the biological sciences.
- C. Principles and concepts:
  1. Fundamental life processes are the same in all living things.
  2. Protoplasm is the living material of the cell.
  3. The work of chlorophyll is essential to all living things.
  4. To better carry on the functions of the higher organisms, cells are organized into tissues, tissues into organs, and organs into systems.
  5. Living things come only from other living things of the same kind.

6. Living things are organized in form and function to carry on activities that sustanin life.
7. Living things are composed of matter, mainly elements and compounds.
8. Throughout the life of every organism there is a building up and a tearing down of protoplasm with constant transformation of energy.
9. The gases in the air furnish the gaseous environment for life.
10. The energy which makes possible the activity of most living things came at first from the sun, and is secured by the organism through oxidation of food within its body.
11. Living things and their environment are interdependent.
12. Animals are ultimately dependent upon green plants for food and oxygen.
13. Green plants differ from all other organisms in that they capture light energy and use it to make carbohydrates.
14. Living things maintain a constant internal environment in face of change.

D.. Content:

1. Theories of the origin of life
    a. Spontaneous generation
    b. Biogenesis
    c. Abiogenesis

2. Characteristics of living things
    a. Constant energy requirement
    b. Cellular organization
    c. Definite form and size
    d. Capable of growth
    e. Capacity to reproduce
    f. Capable of response
    g. Critical relationship with the environment
    h. High adaptative powers
3. Chemical aspects of living matter
    a. Matter
    b. Physical change
    c. Chemical change
    d. Energy
    e. Elements: properties and distribution
        (1) Atom
        (2) Isotopes
        (3) Combining properties of elements: covalent bonds, ionic bonds, molecular bonds
        (4) Compounds
        (5) Molecules
        (6) Mixtures
        (7) Relative abundance and availability of chemicals for life.
    f. Carbohydrates: simple to complex
    g. Fats, fatty acids and glycerol

  - h. Proteins and amino acids
  - i. Nucleic acids
  - j. Enzymes: structure, origin, type and theories of action
- 4. Physical aspects of living matter
  - a. Collodal systems
  - b. Suspensions, emulsions and true solutions
- 5. The structural basis of life
  - a. Formation of cell theory
  - b. Cellular processes
  - c. Parts of a cell
    - (1) Cell membrane: porosity, constituents
    - (2) Structures of the cytoplasm: mitochondria and oxidative enzymes, endoplasmic reticulum, plastids, chloroplasts, pigments, cellular vacuoles, centrioles.
    - (3) The nucleus: chromatin, nucleoli
    - (4) The cell wall: chemical constituents, structure
- 6. Methods of cellular investigation
  - a. Centrifugation
  - b. Radioautography
  - c. Electron microscope
  - d. Light microscopes
- 7. Cellular levels of organization
  - a. Unicellular and colonial
  - b. Tissue level
  - c. Organ level

- d. Organ system
- e. Organism: division of labor, cellular specialization

8. The environmental relationships of the cell
   - a. Homeostasis
   - b. Molecular boundary of a cell
   - c. Passage of materials through cell membranes
     - (1) Permeability of membranes
     - (2) Diffusion
     - (3) Osmosis
     - (4) Active transport
     - (5) Pinocytosis

9. Cellular nutrition
   - a. Source of cellular energy
   - b. Autotrophs--independent organisms
     - (1) Photosynthetic Bacteria
     - (2) Photosynthetic Plants
   - c. Photosynthesis
     - (1) Materials used in photosynthesis
     - (2) Phases of photosynthesis: light, dark
     - (3) Products of photosynthesis
   - d. Chemosynthetic organisms
   - e. Heterotrophs--dependent organisms: symbiotic relationships -- parasitism, mutatism, commensalism
   - f. Saprophytes

10. Cellular metabolism
    - a. Basic syntheses

            - (1) Aerobic
            - (2) Anaerobic
            - (3) Fermentation
        - b. The role of ATP and Krebs' Cycle
    - 11. Cell growth and reproduction
        - a. Growth of cells
        - b. Mitotic division
        - c. The role of DNA
        - d. Types of reproduction
            - (1) Sexual
            - (2) Asexual
        - e. Fertilization
        - f. Meiosis or reduction division
- E. Experiments or Demonstrations
    - 1. Observation of plant and animal cells (macroscopic and microscopic)
    - 2. Observation of living organisms (macroscopic and microscopic)
    - 3. The measurement of pH
    - 4. Fermentation
    - 5. Identification of the nutrients
    - 6. Chromatography of chlorophyll
    - 7. Carbon dioxide in photosynthesis
    - 8. Role of light in photosynthesis
    - 9. Variations in cell structure
    - 10. Principles of diffusion
    - 11. Mitosis in root tip
    - 12. Prepare hay infusion

F. Motivating Activities

1. Repeat the experiments of Redi

2. Class discussion of Biogenesis vs. Abiogenesis

3. Repeat with modification Needham Experiment

G. Enrichment Activities

1. Report on the position of the viruses in the biotic world.

2. Compare enzymes and catalysts.

3. Make a simple model of a DNA molecule.

H. Teaching Aids

1. Chart--microscope with labeled parts

2. Chart--typical cell

3. Chart--chemical elements

4. Films:

   a. Human Cell and The Cytotechnologist 22½ C S Wexler

   b. Meiosis Sex Cell Formation 16½' B/C JS EBF

   c. Mitosis 22' C JS EBF

   d. Mitosis and Meiosis 16½' B/C JS

   e. Photosynthesis 21' C S EBF

   f. Introduction to Biology

   g. Life in a Drop of Water

   h. Living and Non-living Things

   i. The Cell, Structural Unit of Life

III. The Continuity of Life

A. Problem: How does life continue?

B. Objectives: (next page)

1. An awareness of the part heredity plays in determining the characteristics of organisms.
2. Gaining a knowledge of the laws and principles of heredity.
3. Understanding how traits are passed from parents to offspring.
4. Learning an appreciation of the work of Mendel.
5. Gaining a knowledge of the use of genetics in developing newer plants and animals.
6. Understanding the continous changes that occur in living organisms.
7. Gaining a knowledge of the various reasons for these changes and of the various theories advanced by biologists to explain the changes.
8. Teaching an understanding of how man classifies and names living organisms.

C. Principles and Concepts:

1. Acquired characteristics are those that result from the interaction of inheritance and environment.
2. Inherited characteristics may be traced back through both parents.
3. The characteristics an organism inherits are determined by a complex chemical code carried in the chromosomes of male and female reproductive systems.
4. From the lower to the higher forms of life, there is an increasing complexity of structure.
5. Cells have a limiting size.
6. Sexual fertilization allows for a great recombination of genetic material.

7. Man can breed the general type of animal he wants.
8. Vegetative propagation is important to the production of seedless fruits.
9. Living things change in time.
10. Crossing over occurs during meiosis.
11. The vegetative cell is the 2N cell.
12. Sex-linked traits are inherited as a unit.
13. DNA is considered the master molecule, because it controls all cellular activities directly or indirectly.
14. Living things are classified on the basis of structure, biochemical actions and their larvae.

D. Content:

1. Mendelian Heredity
    a. Mendel's first experiment
    b. Mendel's principles
        (1) Unit character
        (2) Alleles
        (3) Dominance
        (4) Segregation
    c. Monohybrid cross
    d. Incomplete dominance
    f. Probability and genetics
2. Genes and chromosomes
    a. The chromosome theory of inheritance
    b. Sutton's chromosome hypothesis
    c. Sex and chromosomes

- d. Non-disjunction--abnormal segregation of sex chromosomes
- e. Gene linkage and crossing over
- f. The genetic code
    - (1) Nucleic acids
    - (2) DNA and RNA
    - (3) Watson and Crick's DNA model
- g. Bacterial transformation
- h. Genetic control
    - (1) Environment and heredity
    - (2) Mutations--errors in the genetic code
    - (3) Causes of mutations
- i. Cytoplasmic inheritance

4. Genes in human populations
    - a. The nature of human heredity
    - b. Populations genetics
    - c. Sampling a population
    - d. The gene pool
    - e. The Hardy-Wineberg Law
    - f. Twins and heredity
    - g. Inheritance of blood types
    - h. Inheritance of Rh factor
    - i. Sex-linked traits
    - j. Sex-limited traits
    - k. Sex-influenced traits
    - l. Inheritance of diseases
    - m. Intelligence and heredity
    - n. Inheritance of mental disorders

5. Applied genetics
    a. Luther Burbank
    b. Plant breeding
        (1) Mass selection
        (2) Inbreeding
        (3) Outbreeding
        (4) Line breeding
        (5) Mutants
        (6) Polyploidy
    c. Animal breeding
        (1) Pedigree and registration papers
        (2) Crossing of two different species
6. The changing world of life
    a. Homologous structures and vestigial structures
    b. Theories of Lamarch, Darwin and De Vries
    c. The course of evolution
        (1) Straight-line evolution
        (2) Adaptive evolution
        (3) Parallel evolution
        (4) Convergent evolution
    d. The evidences of evolution
        (1) Fossil evidence
        (2) Geographical distribution
        (3) Embryological evidence
        (4) Biochemical evidence

- e. Speciation (Implies sexual reproduction and recombination)
    - (1) Natural selection
    - (2) Mutation
    - (3) Genetic isolation
- 7. The variety of life
    - a. The science of classification
        - (1) Early attempts to classify living things
        - (2) Linnaeus
        - (3) Modern theory of classification

E. Suggested Experiments or Demonstrations

1. Use of a key for identification and classification
2. Demonstration of Punnett Square
3. Examining and crossing fruit flies
4. Family pedigree
5. Similarity in animals or plants
6. Variations in animals or plants
7. Variations among human beings
8. Artificial pollination
9. Laws of change
10. Prepared slides of onion root tip
11. Frequency of human genetic traits
12. Draw and label the stages of mitosis and meiosis
13. Test for colorblindness
14. Test for taste (test paper)

F. Motivating Activities

1. Repeat Pasteur's experiment on spontaneous generation.
2. Study of various populations in the laboratory under controlled conditions.
3. Develop a simple key for local plants and animals.
4. Leaf or flower collections.
5. Insect collections.

G. Enrichment Activities

1. Report on Darwin's Origin of the Species.
2. Report on Burbank's applied genetics.
3. List the new varieties of plants and animals developed by man.
4. Construct models of DNA and RNA.
5. Field trip to natural habitat of plants and animals.
6. Debate: Heredity Versus Environment

H. Teaching Aids

1. Reprints of simple keys
2. Live and preserved specimens of plants and animals
3. Models of mitosis and meiosis
4. Colored snap beads to show genes
5. Films:
    a. Cave Dwellers of Old Stone Age 18 B/W JS EBF
    b. The Cave Comminity 13 C JS EBF
    c. Dinosaur Age 15 B/W EJ FA
    d. Ferns (Evolution of Vascular Plants) 17 C SC EBF
    e. Gene Action 16 C S EBF

- f. Heredity 11 B/W JS EBF
- g. Improving Strains of Livestock 13 B/W JS EBF
- h. Laws of Heredity 15 C B/W JS EBF
- i. Molecule of Heredity 12 C B/W JS EBF
- j. Natural Selection 16' C B/W S EBF
- k. Origin of Land Plants (Liverworts and Mosses) 13' B/W SC EBF
- l. Prehistoric Times (World Before Man) 11' C EJS EBF
- m. Sea, The 26' C JS CN
- n. What is a Bird 16 C JS EBF

IV. Microbiology

A. Problem: What are the various microscopic living things around us, and the important problems which they face to live successfully.

B. Objectives:

1. Understanding the nutritional relationships of microorganisms.
2. Understanding the function of microorganisms in geochemistry, food production and manufacture of usable products.
3. Understanding the role of microorganisms as pathogens.
4. An appreciation of the part microbiologists play in food production, disease prevention and eradication.
5. Improving ability to observe and record pertinent information.
6. Realization of the functions of the algae and fungi in food chains and food webs.
7. Familiarity with names and use of thallophytes common to the locality.

8. Understanding the function of the algae in the evolution of multicellular plants and animals.
9. Realization that the fundamental life processes are the same in all living things.

C. Principles and concepts

1. Fundamental life processes are the same in all living things..
2. The work of chlorophyll is essential to all living things.
3. Saprophytic organisms are responsible for decay by which process the necessary raw materials for growth are released for new organisms.
4. Most cases of fermentation and putrefaction are brought about by living microorganisms.
5. All communicable diseases are caused by microorganisms.
6. A parasitic organism harms its host in various ways and degrees.
7. Bacteria are one-celled organisms that occur almost everywhere; in water, in air, in soils and in the bodies of plants and animals.
8. There are three main kinds of bacteria: the cocci, bacilli, and spirilli.
9. The main phases of the nitrogen cycle are controlled by the bacteria.
10. Common methods of food preservation are drying, refrigeration, the use of chemicals and pasteurization.
11. Fungi are a large group of plants lacking chlorophyll.

12. Algae are simple nonvascular green plants that carry on the process of photosynthesis.
13. Fungi may be beneficial or harmful depending on their source of food.
14. Certain molds, mildews, rusts and smuts are among the most destructive in the entire plant kingdom.
15. A virus cannot duplicate its own structure, it uses the machinery of a cell to form virus particles.

D. Content

1. The viruses
    a. State of viruses
    b. Discovery of viruses
    c. Composition and properties of viruses
    d. Classification of viruses
        (1) Bacterial
        (2) Human
        (3) Plant
    e. The phage viruses and their economic importance
        (1) Human and animal viruses
    f. Viruses and cancer
2. Unicellular organisms having no organized nuclei and no cholorophyll
    a. Louis Pasteur
    b. Food relationships of bacteria
    c. Forms of bacteria
    d. Conditions for growth of bacteria

e. Aerobic and anaerobic bacteria
f. Rickettsiae and spirochetes
g. Bacteria and geochemical cycles
h. How bacteria increase in numbers
i. Beneficial activities of bacteria
  (1) Medicine
  (2) Industry
  (3) Milk and milk products
  (4) Fermented foods
j. The protection of food from harmful bacteria

3. Infectious diseases
  a. Disease and microbes
  b. Koch postulates
  c. How germs are spread
    (1) Air-borne germs
    (2) Germs carried in water and food
    (3) Insect-borne diseases
    (4) Germs spread by direct contact
    (5) Soil-borne diseases
    (6) Germs spread by human carrier
  d. How microorganisms cause disease
    (1) Tissue destruction
    (2) Organ destruction
  e. Defense against microbes
    (1) Structural defenses

      - (2) Cellular defenses
      - (3) Chemical defenses
    - f. Immunity against disease
      - (1) Natural immunity
      - (2) Acquire immunity
    - g. Health Heroes
      - (1) Dr. Edward Jenner
      - (2) Louis Pasteur
      - (3) Emil von Behring
      - (4) Paul Ehrlich
      - (5) Alexander Fleming
      - (6) Dr. Selman Waksman
- 4. The protozoans
    - a. Morphology
    - b. Life processes
    - c. Relationship to other organisms
    - d. Examples - amoeba, euglena, paramecium, plasmodium
    - e. Pathogenic protozoa
    - f. Economic importance of protozoa
- 5. The fungi
    - a. General characteristics
    - b. Life processes
    - c. Relationship to other organisms
    - d. Examples: molds, mildews, yeasts, rusts, smuts, and mushrooms.
    - e. Economic importance of fungi

6. The algae
    a. General characteristics
    b. Life processes
    c. Relationship to other organisms
    d. Examples: blue-green, green, diatoms, dinoflagellates, red algae and the brown algae
    e. Economic importance of the algae

E. Experiments
1. Laboratory culture of bacteria
2. Collecting bacteria from various objects
3. Effect of weather conditions on the bacterial count of the atmosphere
4. Differential staining
5. Dillution and plating out samples
6. Bacteriological analysis of milk products
7. Bacteriological analysis of water supplies
8. The inhibitory effects of various anticeptics on bacteria
9. Effect of antibiotics on bacteria
10. Observation of various protozoans
11. Culturing protozoans
12. Responses of unicellular organisms to stimuli
13. Growing bread mold
14. Blue and green molds
15. Study of yeast
16. Structure of mushroom
17. Collection, examination and identification of fresh water algae.

18. Examination of root nodule bacteria
19. Spread of bacteria by droplet infection
20. How yeast makes bread rise
21. Microorganisms in a fish tank
22. Prepare hay infusion

F. Motivating Activities

1. Display of various species of mold
2. Make algal cookies
3. Set up a terrarium
4. Demonstration of bacterial pegments and phosphorescent
5. Making spore prints
6. Prepare a display of vaccines, antitixins, sulfa drugs
7. Prepare a display of man's methods of preserving foods and preventing spoilage

G. Enrichment Activities

1. Report on important fermentative action by microorganisms
2. Report - "Algae and Man's Food Supply"
3. Report - "Health Heroes"
4. Report - "Preparation of Flax and Hemp"
5. Grow edible mushrooms (use kit)
6. Report - "The Role of Bacteria in Sewage Disposal"
7. Report - "Florida's Red Tide"
8. Report of the development of disease resistant crops
9. Report on the dangers of insects as disease carriers

H. Teacher Aids

1. Microscope

2. Live cultures of:
    a. Algae
    b. Fungi
3. Mushroom growing kits
4. Charts
    a. Fungi types
    b. Algal types
    c. Life cycles of algae and fungi
    d. Growth rate of microorganisms
    e. Distribution of microorganisms
5. Autoclave
6. Distillation apparatus
7. Refrigerator
8. Health Heroes sets
9. Field trips
    a. Woodland bog
    b. Sewage treatment plant
    c. Water purification plant
    d. Health departments
        (1) City
        (2) County
        (3) State
10. Films:
    a. Bacteria 19' C SC CN
    b. Fresh Water Pond 14' B/W EJ EBF
    c. Life Between Tides 11 C EJ EBF

d. Life in a Cubic Foot of air 11' C EJS CN

e. Life in a Drop of Water 11' B/W EJS CN

f. Life Story of Paramecium 11 C EJ EBF

g. Fungi 15' C JS EBF

h. Micro-Activities 15' B/W S U of Ind.

i. Micro-organisms (Beneficial Activities) 15' B/W S of Ind.

j. Microscopic Life (World of the Invisible) 14' B/W EJ EBF

k. Plankton and the Open Sea 19' C JSC

l. Protozoa 11' C S CN

m. Simple Plants - The Algae 16' C JS EBF

V. The Higher Plants

A. Problem: What are the structures, requirements and life functions of a multicellular plant.

B. Objectives:

1. Understanding of the place of vascular plants in the plant kingdom and the complexity and efficiency of of their tissues and organs.
2. Understanding of seed germination and the conditions required for germination.
3. Knowledge of the make-up of a flower and the reproductive process.
4. Familiarity with the reproductive cycles of various plants.
5. Awareness of problems relating to plant growth and reasons for distribution of plants in different environments.
6. Understanding of vegetative propagation of plants, cuttings, budding and grafting.
7. Acquaintance with fruits and seeds and the way in which plants disperse or relocate in these stages.
8. Development of skill in studying tissues and organs in detail.
9. Awareness of the economic importance of our natural resources.
10. Recognition of the relationship of mosses and ferns and their relationship to the thallophytes as well as to complex plants.

C. Principles and Concepts:

1. The plant kingdom is very diverse.
2. Plants are adapted to their environment.
3. Green plants make their own food.
4. Plants and animals are interdependent.
5. Plants make responses to environment.
6. Some plants reproduce sexually or asexually or both.
7. The flower is the main reproductive organ of a plant but in some plants the roots and stems serve as organs of reproduction.
8. The major function of the leaf is photosynthesis.
9. The structure and function of plants are complimentary.
10. Water conducting tubes enable green plants to live in a land environment while plants without these tubes must be adapted to certain environmental conditions.
11. Plants are highly adapted for pollination, fertilization, and dispersal.
12. Some plants produce seeds.

D. Content

1. Divisions of the plant kingdom
    a. Thallophyta
    b. Bryophyta
    c. Tracheophyta
2. Complex plants without fluid-conducting vascular systems
    a. True mosses
        (1) Structure
        (2) Reproduction and life cycle
        (3) Economic Importance

- b. The liverworts
  - (1) Structure
  - (2) Reproduction and life cycle

3. Primitive plants with fluid-conducting vascular systems
   - a. Ferns
     - (1) Reproduction
     - (2) Life Cycle
   - b. Relatives of the ferns
4. Spermatophytes - seed producing tracheophytes
   - a. The gymnosperms
     - (1) Characteristics
     - (2) Cone bearing specimens
     - (3) Economic Importance
   - b. The angiosperms
     - (1) Dicotyledonous
     - (2) Monocotyledonous
     - (3) The plant body of a flowering plant
     - (4) Woody and herbaceous
5. Root Structures and functions
   - a. Root systems
   - b. General structures
     - (1) External
     - (2) Internal
   - c. General Functions
   - d. Reproduction
   - e. Economic Importance

6. Stem structure and functions
    a. Herbaceous stems
        (1) External structure
        (2) Internal structure
    b. Woody stems
        (1) External structure
        (2) Internal structure
    c. Conduction of liquids
    d. Vegetative propagation
    e. Economic Importance
7. Leaves and their functions
    a. Structure of the leaf
        (1) Internal
        (2) External
    b. Functions of the leaf
        (1) Transpiration
        (2) Photosynthesis
    c. Forms of Leaves
    d. Arrangement of leaves on stem
8. Flowers, Seeds and Fruits
    a. Structure of a flower
    b. Function of a flower
    c. Pollination
    d. Fertilization
    e. Seed Structure
    f. Types of seeds

        - g. Germination of seeds
        - h. Seed dispersal
        - i. Types of fruits
        - j. Formation of fruits
    - 9. Plant adaptation and survival

E. Experiments and/or demonstrations

1. Photosynthesis
    - a. Requirements for photosynthesis
    - b. By-products of photosynthesis
    - c. Rate of photosynthesis under varying environmental conditions
2. Respiration in germinating seeds
3. Structure and germination of pollen grains
4. Response in plants
5. Mineral requirements of plants
6. Effect of mineral deficiency on the growth of seedlings.
7. Vitamins as plant stimulators
8. External structure of a woody stem
9. Dissection of a terminal bud
10. Apical dominance of a terminal bud
11. Tissues of herbaceous dicot and monocot stems
12. Vegetative propagation
13. Water rise in a stem
14. Tissues of a leaf
15. Transpiration
16. Structure of a flower

17. Start seeds for outdoor planting

F. Motivating Activities
    1. Cross pollinate flowers
    2. Make a leaf collection
    3. Make various leaf tracings
    4. Develop plants vegetatively

G. Enrichment Activities
    1. Make a study of local flora
    2. Make a report on Florida's important trees
    3. Debate the value of flora in maintaining Florida's soils
    4. Grow a small vegetable garden
    5. Dry flowers - develop various floral arrangements

H. Teacher Aids
    1. Models
        a. X-sections of monocot stem
        b. X-section of dicot stem
        c. X-section of green leaf
        d. Longitudinal section of various stems
    2. Charts
        a. Carbon-oxygen cycle
        b. Nitrogen cycle
        c. National parks and forest regions
    3. Field trips
        a. Botanic garden
        b. Experimental station

a.

c. A nursery

d. Nearby woods

4. Films:

a. Angiosperms - Flowering Plants 16' C JS EBF

b. Asexual Reproduction 10' B/W JS U of Ind.

c. Carnivorous Plants 10' C JS Moody

d. Characteristics of Plants and Animals 10' C S EBF

e. Distribution of Plants and Animals 16' C SC EBF

f. Flowers at Work 11' C EJS EBF

g. Forest Produces 11' C JS CN

h. Fungus Plants 11' B/W EJS EBF

i. Gymnosperms 16' C JS EBF

j. Growth of Flowers 11' C EJS CN

k. Growth of Plants 11' B/W EJS CN

l. Growth of Seeds 11' B/W EJS EBF

m. How Flowers Make Seeds 11' C EJ EBF

n. How Green Plants Make and Use Food 11' B/W JS EBF

o. How Pine Trees Reproduce 11' B/W SC EBF

p. Leaves 11' B/W EJS EBF

q. Life of a Plant 11' B/W JSCA EBF

r. Osmosis 16' C S EBF

s. Photosynthesis 21' C S EBF

t. Plant Growth 11 B/W EJS EBF

u. Plant Motions-Roots, Stem and Leaves 11 B/W EJS EBF

v. Plant Traps 11 C JS EBF

w. Reproduction in Plants 13½ B/W JS CN

x. Roots of Plants 11 B/W EJ EBF

y. Seed Dispersal 11 B/W JSC EBF

z. Seed Germination 14 C JS EBF

aa. Trees How we Identify Them 11 C EJ CN

VI. The Invertebrates and How They Live

A. Problem: What are the structures, requirements, and economic importance of the invertebrates?

B. Objectives:

1. Understanding of the development of tissues, and then the development of the metazoa.
2. Understanding of parasitism among flatworms and roundworms, and of the life cycles of the organisms in various hosts.
3. Familiarity with health measures involved in the prevention of parasitic worms.
4. Acquaintance with Echinoderms and Mollusks as complex invertebrates.
5. Knowledge of the advantages and the limitations of multicellularity.
6. Familiarity with common insects.
7. Knowledge of the principles of analogy, homology and regeneration in various arthropods.
8. Knowledge of insect control measures.
9. The ability to classify insects into orders on basis of metamorphosis and general structure.
10. Knowledge of the diverseness in the structure and activities of insects.

11. Familiarity with the economic importance of the invertebrates.

C. Principles and Concepts:

1. Animals without backbones are invertebrates.
2. Invertebrates have a variety of adaptations which allow them to inhabit certain environments.
3. Multicellular organisms exhibit a division of labor.
4. All metazoans are dependent on plants and other animals.
5. The simple metazoans are at the tissue level of biological organization.
6. Invertebrates show all types of interrelationships. (Parasitism, etc.)
7. Animals are grouped by their structural relationships.
8. Symmetry is the general body plan of an organism.
9. Some invertebrates developed a primitive central nervous system.
10. Many worms are human parasites
11. Some invertebrates serve as a source of food.
12. The annelids are at the system level of biological scale.
13. Similar larvae are considered to indicate a close relationship.
14. The insect's body is divided into three regions.
15. The arthropod's growth is limited by his skeleton.
16. Most insects undergo some form of metamorphosis.
17. The sexes are separate in most insects.
18. Fruit production is dependent upon the activities of certain insects.
19. Insects are carriers of many harmful organisms.

20. Man must control insects to maintain his comfortable position.
21. Invertebrates are important to man,because some are harmful and others are helpful.

D. Content:

1. Sponges and Coelenterates
   a. Morphology
   b. Life processes
   c. Relationship to other forms
   d. Examples
   e. Economic importance
2. Body plans of organisms
   a. Anterior
   b. Posterior
   c. Dorsal
   d. Ventral
   e. Bilateral symmetry
   f. Radial symmetry
3. Platyhelminthes
   a. Morphology
   b. Life processes
   c. Relationship to other forms
   d. Economic importance
   e. Examples
4. Nemathelminthes
   a. Morphology
   b. Life processes

   - c. Relationship to other forms
   - d. Economic importance
   - e. Examples

5. Annelida
   - a. Morphology
   - b. Life processes
   - c. Relationship to other organisms
   - d. Economic importance
   - e. Examples
6. Mollusca
   - a. Morphology
   - b. Life processes
   - c. Relationship to other organisms
   - d. Economic importance
   - e. Examples
7. Echinodermata
   - a. Morphology
   - b. Life processes
   - c. Relationship to other organisms
   - d. Economic importance
   - e. Examples
8. Arthropoda (Crustaceae)
   - a. Morphology
   - b. Life processes
   - c. Relationship to other organisms
   - d. Distribution and economic importance

    - e. Examples
- 9. Arthropoda (Arachnida, Chilopoda and Diplopoda)
    - a. Morphology
    - b. Life processes
    - c. Relationship to other organisms
    - d. Distribution and economic importance
    - e. Examples
- 10. Arthropoda (Insecta)
    - a. Morphology
    - b. Life processes
    - c. Relationship to other organisms
    - d. Distribution, economic importance, and control.
    - e. Examples (Eight orders and representatives from each.)

E. Experiments and/or Demonstrations

- 1. Examine species of Hydra.
- 2. Examine sponge skeletons.
- 3. Set up aquariums.
    - a. Aquatic
    - b. Marine
- 4. Examine preserved specimens of the invertebrate phyla.
- 5. Examine diseased organisms for endo-parasites.
- 6. Examine various living invertebrates.
- 7. Dissect and study organs of earth worm.
- 8. Culture various small invertebrates.

F. Motivating Activities

1. Construct an insect nest, record and report of the activities of the inmates.
2. Collect and mount ten insect orders.
3. Make a study on the effectiveness of insecticides.
4. Field trip:
    a. Small pond or stream
    b. Collect small animals from soil sample and examine.
    c. Observation of bees, wasps, ants

G. Enrichment Activities
1. Report on the Fruit Fly.
2. Report on various Crustaceans used as a source of food.
3. Florida and The Sponge Industry
4. Observe honey bees and note their relationship to certain flowers.
5. Visit by county agricultural agent

H. Teaching Aids
1. Various invertebrate models
2. Ant colony
3. Chart of the insect world
4. Chart--Phylo-genectic Arrangement of Animal Kingdom
5. Living and preserved specimens of invertebrates
6. Diagrams of internal anatomy of selected invertebrates
7. Films:
    a. Adaptive Radiation 18 C JS EBF
    b. Amphibian Embryo 16 C SC EBF
    c. Ants 11 B/W EJS EBF

d. Arthropods 18' C SC EBF

e. Beach and Sea Animals 11' B/W EJS EBF

f. Butterflies 11' B/W EJS EBF

g. Cicada (Insect Methuselah) 17' C JS Moody

h. Crustaceans 13' C JS EBF

i. Flatworms 16' C S EBF

j. Flies and Mosquitoes 10' B/W EJ EBF

k. Honey Bee 11' B/W JS EBF

l. House Fly 11' B/W JS EBF

m. Introducing the Insects 17' B/W EJ EBF

n. Bumblebee, The 11' B/W EJ M.D.

o. Echinoderms, The 16' C JS EBF

p. Grasshopper, Typical Insect 5' C JSCA CN

q. Insect Life Cycle 11' B/W JS EBF

r. Insects and Spiders 11' C EJS EBF

s. Life Story of a Moth 11' C EJ EBF

t. Life Story of the Crayfish 10' C EJ EBF

u. Metamorphosis (Life Story of the Wasp) 14' C JS EBF

v. Monarch Butterfly Story 11' C EJS EBF

w. Parasitism (Parasitic Flat Worms) 17' SC SC EBF

x. Pond Insects 11' B/W JS EBF

y. Segmentation 16' C JS EBF

z. Spiders 11' C EJS EBF

aa. Spiders Engineering 15' B/W EJS Moody

bb. Stinging Celled Animals (Coelenterates) 16' C JS EBF

cc. Story of the Bees 20' B/W EJS United

VII. Vertebrates and How They Live

A. Problem: What do we know of the intricate machinery that enables vertebrates to surpass all others in structural organization and functional efficiency.

B. Objectives:

1. Knowledge of the position of vertebrates in the biosphere.
2. Familiarity with the uniqueness of the vertebrates.
3. Knowledge of the unimaginably complex vertebrate body and how it functions.
4. Knowledge of the increase in complexity of the organs of the vertebrate from the lower forms to mammals.
5. Cognizant of the economic importance of the vertebrates.
6. Expand the student acquaintance with vertebrates of his region.
7. Interest in the relationship that exist between conservation and vertebrates.
8. Developing knowledges that are important to the study of human biology.
9. Introduction of hobbies and leisure-time activities involving vertebrates in some manner such as taxidermy, collection, field study and similar experiences.

C. Principles and Concepts:

1. Vertebrates are animals with backbones.
2. Vertebrates have a highly developed brain and nervous system.
3. Classes of vertebrates increase in complexity from fish to mammals.

4. Vertebrates use various devices for securing oxygen.
5. The egg may be fertilized internally or externally, but external fertilization is very hazardous.
6. The vertebrate skeleton is internal and of bone or cartilage.
7. Pisces, Amphia and Reptilia are cold-blooded. Mammals are warm-blooded.
8. Although most reptilia are harmless, some are poisonous.
9. Many birds are flightless, and some mammals fly.
10. All animals have some water regulating device.
11. Mammals can regulate their internal environment.
12. Transportation is vital to vertebrates, and they have many methods of locomotion.
13. Instinct and intelligence are vital to survival.
14. Vertebrates are used for food, pets, and beasts of burden.

D. Content:

1. Introduction to the vertebrates
    - (a) Classes of vertebrates
    - (b) Outstanding characteristics
    - (c) Body systems
    - (d) Lines of development
2. Fish and fish-like vertebrates
    - (a) Vampires of the water
    - (b) Sharks and rays
    - (c) True Fish
    - (d) Structure of true fish
    - (e) Body systems of fish

   (f) Swim bladder
   (g) Economic importance
3. Amphibia - Vertebrates with double lives
   (a) Characteristics of amphibia
   (b) Toads
   (c) Frogs
   (d) Body structure of frog and adaptations
   (e) Body systems
   (f) Metamorphosis and hibernation
4. The Reptiles
   (a) Classification
   (b) Adaptation of snakes
   (c) Non-poisonous and poisonous snakes
   (d) Lizards
   (e) Crocodiles
   (f) Turtles
5. The Birds
   (a) Characteristics
   (b) Adaptations
   (c) Structures and functions
   (d) Body systems of birds
   (e) Migration
   (f) Economic importance
6. Mammals
   (a) Characteristics
   [illegible]

        (b) Classification

        (c) Primates

E. Experiments and/or demonstrations

    1. Animal dissections (fish, frog, etc.)

    2. Responses of animals

    3. Circulation in animals

    4. Study of living fish

    5. Regeneration in a tadpole

    6. Effects of drugs and hormones on frog metamorphosis

    7. Reflexes in the frog

    8. Frog egg development

    9. Incubating chick eggs (use series study)

    10. Preparation of various vertebrate skeletons

    11. Comparision of bird brain and fish brain

    12. Dissection of the fetal pig

F. Motivating Activities:

    1. Direct and photographic observations of birds

    2. Build a bird feeding station.

    3. Raise white mice.

    4. A collection of old bird nests

    5. Prepare bulletin board with animal pictures.

    6. List the uses of mammals.

G. Enriching Activities:

1. Prepare reports on:
    - (a) Whales and whaling
    - (b) Intelligence of apes
    - (c) Migration of birds
    - (d) Giant Dinosaurs
    - (e) Poisonous Snakes
2. Report on local animal superstitions
3. Debate on the value of birds

H. Teaching Aids

1. Terrarium
2. Live and preserved mammals
3. Charts and models of mammals
    - (a) External structure
    - (b) Internal structure
4. Films:
    - (a) Amphibians Frog, Toads and Salamanders 11' B/W EJS FA
    - (b) Animals in Moler Life 11' B/W EJS EBF
    - (c) Beginning of Vertebrate Life 11' B/W JS EBF
    - (d) Biography of a Fish 10' B/W JS EBF
    - (e) Biography of the Unborn 16' B/W A EBF
    - (f) Blind as a Bat 7' B/W EJS Moody
    - (g) Camoflage in Nature Through Pattern Matching 7½' C JS CN
    - (h) Chick Embryo, The 13' C JS CN
    - (i) Development of a Chick 10' B/W JS EBF
    - (j) Fish Embryo (Fertilization to Hatching) 12' C S EBF
    - (k) First Many Celled Animals (sponges) 15' B/W JS EBF

(l) Frog, The 11' B/W EJSCA EBF

(m) Frogs and Toads 11' B/W EJS CN

(n) Hare and Tortoise 10' B/W PEJS EBF

(o) Hibernation and Forms of Dormacy 11' B/W EJ EBF

(p) Life in the Ocean 17' C EJ FA

(q) Life Story of a Crayfish 10' C EJ EBF

(r) Life Story of a Snake 11' C EJ EBF

(s) Life Story of a Snail 10' C EJ EBF

(t) Life Story of a Toad 11 B/W EJS F.A.C.

(u) Marine Animals and Their Foods 11 B/W JS CN

(v) Migration of Birds (Canada Goose) 11 C EJ EBF

(w) Pigs and Elephants 10 B.W PEJS CN

(x) Raccoons Picnic, The 5 C PS EBF

(y) Reptiles 14 C EJSCA EBF

(z) Snakes 10 B/W EJS EBF

(aa) Snapping Turtle 11 B/W EJS Chgo AC

(bb) Sunfish 11 B/W EJS EBF

(cc) Water Fowl in Action 11 C EJS U of Minn.

(dd) What is a Mammal 14' C JSC

(ee) What is a Fish 22 C SC

(ff) What is a Reptile 18 C JS EBF

(gg) What is an Amphibian 11 C JS EBF

VIII. The Biology of Man

A. Problem: What do you know about yourself?

B. Objectives:

1. An appreciation for the revelation of man's inheritance through the ages.
2. Better understanding of the human body as a complicated unit of life.
3. Knowledge of the tissues, organs and systems composing the human body.
4. Understanding of the similarities and differences between the human body and that of other vertebrates.
5. Knowledge of man's superiority among living things resulting from the high development of human nervous system.
6. Knowledge of the human body and its activities which should result in better health habits and understanding of health problems.
7. Knowledge of the dangers resulting from the use of alcohol, tobacco and narcotics.
8. Knowledge of human reproductive system.
9. Knowledge of human development.
10. Understanding of man's dependence on other living organisms.
11. Increased knowledge of the interactions of systems and processes in supplying needed nutrients and essential substances and the elimination of cellular waste.

C. Principles and Concepts:

1. Fossils furnish evidences of the ecology of past environments.
2. The structure of the skeletal and muscular systems gives the human body its size, shape and posture.

3. The contraction and relaxation of muscles permits movement of the body.
4. The digestive and circulatory systems supply the body cells with the substances from the environment which they need for growth, repair and energy.
5. Nutrients are made ready for absorption in the digestive system.
6. The blood system maintains the internal environment required by every living cell.
7. Man's sense organs and his central nervous system enable him to be aware of his environment and react to it.
8. An organism may inherit certain characteristics and acquire others through the influence of its environment.
9. Through cell cleavage, differentiation and specialization the zygote develops into an embryo.
10. Intelligence, ingenuity and creative ability are making man the master of every environment on earth and in space beyond.

D. Content:

1. The human species
    - (a) The origin of man
    - (b) The taxonomy of man
    - (c) Fossils
        - (1) formation
        - (2) dating
        - (3) reconstruction

d. Remote ancestors of man
  - (1) Proconsul (man like apes--East Africa)
  - (2) Australopithecus (man like apes--South Africa)
  - (3) Zinanthropus

e. More recent ancestors of man
  - (1) Java man
  - (2) Neanderthal man
  - (3) Cro-Magnon man

f. Modern man

g. Physiology and modern races

h. The framework of the body
  - (1) tissues of the human body
  - (2) organs and systems of the human body
  - (3) the body regions of man
  - (4) functions of the skeleton
  - (5) development of bone tissues
  - (6) structure of bone
  - (7) axial skeleton
  - (8) appendicular skeleton
  - (9) ligaments and joints
  - (10) care of the bones

i. Muscles of the body
  - (1) the kinds of muscles
  - (2) contraction of muscles
  - (3) chemistry of muscle action
  - (4) tonus and tetanus

j. Food and nutrition
    (1) function of nutrients
    (2) essential raw materials
        (a) inorganic nutrients
        (b) organic nutrients
    (3) the vitamins
        (a) natural
        (b) synthetic
        (c) classification and use
    (4) the organs and processes of digestion
        (a) the mechanical phase of digestion
        (b) the chemical phase of digestion
        (c) the role of the liver and pancreas
        (d) absorption and elimination
    (5) care of the digestive tract
        (a) oral hygiene
        (b) constipation
    (6) balanced diets
    (7) food and drug laws

k. Transport and excretion
    (1) the circulatory system
    (2) the composition of blood
        (a) blood plasma
        (b) solid components
    (3) function of cellular components

      - (a) red blood cells (erythrocytes)
      - (b) white blood cells (leucocytes)
      - (c) platelets
    - (4) blood groups and transfusions
    - (5) the Rh factor
    - (6) structure and function of heart
    - (7) types, structure and functions of the blood vessels
    - (8) circulation in the body
      - (a) pulmonary
      - (b) systemic
    - (9) lymph and the lymphatic system
    - (10) heart disease
- l. Structure and functions of the kidneys
- m. Structure and functions of the skin
- n. Respiration and energy exchange
  - (1) the mechanism of breathing
  - (2) internal respiration
  - (3) external respiration
  - (4) structures and functions of respiratory tract
    - (a) nose and pharynx
    - (b) epiglottis and trachea
    - (c) bronchi and lungs
  - (5) mechanics of breathing
    - (a) breathing movements
    - (b) control of breathing
    - (c) air capacity of lungs

- (6) artificial respiration
- (7) respiratory disorders
- (8) external influences on breathing and respiration
- (9) carbon-monoxide poisoning
- (10) respiration at high altitudes

o. The nervous system

- (1) the two systems
  - (a) central
  - (b) autonomic
- (2) central nervous system
  - (a) brain
  - (b) cranial nerves
  - (c) spinal cord
  - (d) spinal nerves
- (3) the structure and types of nerves
  - (a) dendrite
  - (b) axon
  - (c) afferent nerves
  - (d) efferent nerves
  - (e) plexuses
  - (g) synapse
- (4) parts of the brain and their functions
  - (a) membranes of brain
  - (b) the cerebrum
  - (c) the cerebellum
  - (d) medulla
  - (e) pons

(5) nervous reactions
  (a) reflex actions
  (b) conditioned reflex
  (c) voluntary acts
  (d) instinctive behavior
  (e) habit forming
  (f) reasoning
  (g) emotion
(6) the autonomic nervous system
  (a) sympathetic system
  (b) parasympathetic system
(7) receptors in the skin
(8) the sense of taste
  (a) location of taste buds
  (b) four common flavors
(9) the sense of smell
  (a) location of olfactory nerve buds
  (b) how a person smells
(10) the human ear
  (a) structure
  (b) function
  (c) equilibrium
  (d) care of ears
(11) the human eye
  (a) structure
  (b) function

        - (c) comparison of eye and camera
        - (d) defects of the eye
        - (e) care of the eyes

- p. Alcohol, narcotics and tobacco
    - (1) alcohol in the body
        - (a) effects of alcohol on the body organs
        - (b) effects of alcohol on the nervous system
    - (2) the problems of alcoholism
        - (a) alcoholism is a disease
        - (b) alcohol and life span
        - (c) alcohol and society
        - (d) alcohol and driving
    - (3) tobacco and nicotine
    - (4) narcotic drugs
    - (5) barbiturate problem
    - (6) federal and state regulations
- q. Internal regulation and coordination
    - (1) hormones
    - (2) endocrine glands
        - (a) thyroid gland and its hormone
        - (b) parathyroid gland and its hormone
        - (c) the pituitary or "master gland"
        - (d) the pancreas and its hormones
        - (e) the adrenal gland and its hormone
        - (f) the sex glands and their hormones
        - (g) pineal body and thymus gland
    - (3) dynamic balance in endocrine glands

r. Reproduction and development
    (1) sexual reproduction
        (a) male reproductive system
        (b) female reproductive system
    (2) production of gametes
        (a) oogenesis
        (b) spermatogenesis
    (3) ovarian and uterine cycles
    (4) hormone control of uterine cycle
    (5) fertilization of ovum
    (6) embryonic development
        (a) zygote
        (b) cleavage
        (c) primary germ layers
    (7) birth of fetus

E. Experiments and/or Demonstrations:

1. Rate of digestion in frogs
2. Nutritional experiments
3. Movement of organs in body of frog
4. The role of pepsin in digestion
5. Test for nutrients
6. Action of ptyalin on starch
7. Action of pepsin on protein
8. Study of blood cells
9. Examination of external and internal structure of a long bone

10. Demineralization of bone
11. Analysis of bone ash
12. Effect of temperature on enzyme action
13. Microscopic examination of frog's foot (to show circulation)
14. Blood typing
15. Structure of the heart (small mammal)
16. Study of muscle types
17. The chemical senses--taste and smell
18. Sensations on the skin
19. Sugar test of urine for diabetes
20. Draw an outline of human--locate all major organs
21. Heartbeat in frog
22. Carbon-dioxide test
23. Dissect various animals: trace out excretory system in each.
24. Bisect kidney from mammal.
25. Examine skin under microscope
26. Demonstrate striated muscle

F. Motivating Activities:

1. Models of various organs
2. Draw your family tree.
3. Incubate fertile and non-fertile chicken eggs.
4. Find difference between white bread and whole wheat bread.
5. Trace the different classes of foods back to their origin. in chemical activity of the green plant.
6. Count calories in average serving of lunch in cafeteria.

7. Dissect female cat or rabbit (pregnant if possible); note location of fetuses.
8. Make model of arm or leg, and show how the bones and muscles must work together.
9. Description of the result of a reflex
10. Learning sense and nonsense rhymes
11. Testing taste
12. Learning rates of certain mammals

G. Enrichment Activities:

1. Make a report on the history of pellagra.
2. Make a report on how plants make sugar and how sugar is changed to starch.
3. List action on favorite food as it is digested.
4. Make a report of importance of cleanliness and proper diet to excretion.
5. Report on cause and prevention of acne, pimples and boils.
6. Draw your family tree.
7. Make report of venereal disease.
8. Start a booklet on service systems of the human body. Put in drawing of the skeleton, structure of the bone, kinds of joints, kinds of muscles and their location in the human body.
9. Construct a maze and train hungry rat to locate food.
10. Conditioning of an animal by using a primary and secondary stimulus to initiate response
11. Make a report on the effects of LSD in man.

12. Show the correlation between drinking and auto deaths.
13. The effect of narcotics on moral training

H. Teaching Aids:

1. Charts, booklets, models
    a. Human torso
    b. Digestive system
    c. Villi chart on model
    d. Calorie charts
    e. Vitamin sources, diseases of vitamin deficiencies
    f. Food charts
    g. Chart of breathing organs
    h. Model of lungs
    i. Chart and model of kidney
    j. Chart and model of skin
    k. Chart--human development
    l. Slides of cross sections of ovary and testes
    m. Slides of muscle types
    n. Chart and model of heart
    o. Prepared slides of human blood, various staining techniques
    p. One pint of citrated blood
    q. Chart and model of human skeleton showing muscles, bones, and joints
    r. Models of all sensory organs
    s. Chart on brain and nerves
    t. Model of respiration

2. Field Trips:
    a. Visit milk pasteurizing plant.
    b. Visit packing house.
    c. Visit State Board of Health.
    d. Visit hospital laboratory.
    e. Museum

3. Films:

a.	Admirals In The Making	13½'	C	JS	Stark
b.	Alcohol and The Human Body	14'	B/W	JS	EBF
c.	Alimentary Tract	11'	B/W	JS	EBF
d.	Allergies	12'	B/W	JS	EBF
e.	Antibiotics	14'	B/W	JS	EBF
f.	Atom and Medicine	12'	B/W	JS	EBF
g.	Blood, The	16'	C	JS	EBF
h.	Body's Defenses Against Disease	11'	B/W	JS	EBF
i.	Circulation	16'	B/W	JS	United
j.	Digestion of Foods	11'	B/W	JS	EBF
k.	Drug Addiction	22'	B/W	JS	EBF
l.	Ears and Hearing	10'	B/W	JS	EBF
m.	Endocrine Glands	11'	B/W	JS	EBF
n.	Eyes and Their Care	11'	B/W	JS	EBF
o.	Eyes and Vision	10'	B/W	EJ	EBF
p.	First Aid	11'	B/W	JS	EBF
q.	Food Getting Among Animals	13'	C	JS	Moody
r.	Foods and Nutrition	11'	B/W	S	EBF
s.	Fundamentals of the Nervous System	16'	C	JS	EBF

t.	Harvest of Convenience	22½'	C	EJS	Gen.Foods
u.	Heart and Circulation	11'	B/W	JS	EBF
v.	Heart, Lungs, and Circulation	11'	C	EJ	CN
w.	How Animals Defend Themselves	10'	B/W	JS	McGraw
x.	How Animals Move	11'	B/W	EJ	Young Amer.
y.	How Our Bodies Fight Disease	8'	B/W	EJ	EBF
z.	How The Eye Functions	15'	B/W	JSCA	
aa.	Human Brain, The	11'	B/W	JS	EBF
bb.	Human Cell and The Cytatechnologists	22½'	C	S	Wexler
cc.	Human Machine	14'	B/W	JS	Moody
dd.	Human Skeleton	10'	B/W	JS	United
ee.	Mechanism of Breathing	11'	B/W	JS	EBF
ff.	Meiosis: Sex Cell Formation	16'	C	S	EBF
gg.	Mental Health	12'	B/W	JS	EBF
hh.	Mitosis	22'	C	JS	EBF
ii.	Mitosis and Meiosis	16½'	B/C	JS	EBF
jj.	Nose, The (Structure and Function)	11'	C	JSA	EBF
kk.	Nervous System	11'	B/W	JS	EBF
ll.	Physical Aspects of Puberty	19'	B/W	SA	McGraw
mm.	Planning Good Eating	8'	B/W	EJS	American
nn.	Posture	10'	B/W	EJS	EBF
oo.	Posture and Exercise	11'	B/W	EJS	EBF
pp.	Skeleton, The	13'	B/W	JS	EBF
qq.	Spinal Column	11'	B/W	SC	EBF
rr.	Teeth	11'	B/W	JS	EBF
ss.	Tobacco and The Human Body	22'	B/W	JS	EBF

tt.	Ulcer At Work	25	B/W	S	
uu.	Work of The Blood	13	C	JS	EBF
vv.	Work of The Kidneys	11	B/W	JS	EBF
ww.	Your Daily Bread	12	C	EJS	ABS
xx.	Your Eyes	11	B/W	EJ	Young Amer.

IX. Living Populations and their Interdependence

A. Problem: How are living things related to each other and to the environment?

B. Objectives:

1. An appreciation of plant and animal societies that live in critical relationships with each other.
2. Understanding of the problems involved in the survival of living things.
3. Understanding of energy levels and their relationship to biological succession.
4. A knowledge of the use and reuse of materials in nature.
5. Understanding the physical and chemical factors in the environment which affect the abundance or scarcity of living things in a given environment.
6. An appreciation of the wise and efficient use of our natural resources.
7. Better understanding of our state and national parks and recreational areas as conservational measures.

C. Principles and concepts:

1. All plants and animals are constantly engaged in a struggle for energy.
2. Plants and animals are directly or indirectly dependent upon geochemical cycles for essential elements.
3. Balance of nature is maintained through the interrelations of plants with each other and with their physical environment.
4. Living things are not distributed uniformly over the surface of the earth but are found in definite zones and local regions that are favorable to their survival.
5. Supplying food to vastly increasing numbers of people is becoming an urgent problem.
6. The diverse forms of life have found niches in the different terrestrial, marine and fresh water environments.
7. Periodic changes in communities are brought about by regular variations in light,temperature, and climatic conditions.
8. Changes in the earth's topography are caused by erosion, volcanic eruptions, earthquakes, and flooding.
9. Succession occurs in any cleared area.
10. Floods and droughts can be reduced or prevented by controlling soil erosion, restoring forests, restoring backwaters, along the streams and use of flood controlling measures.

D. Content:

1. Introduction to ecology
    a. The environment
        (1) Biosphere
        (2) Ecosystems
        (3) Community or biome

- b. Populations and their effects
- c. Levels of organizations in ecosystem
- d. The physical environment
  - (1) Soil
  - (2) Geochemistry
  - (3) Watercycle
  - (4) Carbon-oxygen cycle
  - (5) Nitrogen cycle
  - (6) Phosphrous cycle
- e. Biological balance

2. The habitat of living things
   - a. Limiting factors of the environment
     - (1) Soil
     - (2) Temperature
     - (3) Light
     - (4) Atmosphere
     - (5) Topography
     - (6) Nutritional relationships
       - (a) Producers
       - (b) Consumers
       - (c) Decomposers
   - b. Food chains and food webs
   - c. Food and population pyramids
   - d. Special nutritional relationships
     - (1) Bulkfeeders
     - (2) Symbiosis
   - e. Passive protection

        - (1) Protective coloration
        - (2) Protective resemblance
        - (3) Mimicry

3. Periodic changes in environment
    - a. Alternating periods of activity
        - (1) Duirnal
        - (2) Nocturnal
        - (3) Periodicity
        - (4) Rhythmic
    - b. Biological clocks
        - (1) Daily rhythms
        - (2) Seasonal changes
        - (3) Lunar rhythms
        - (4) Annual rhythms
    - c. Ecological successions and climax associations
        - (1) Changing biotic communities
        - (2) Natural succession in a forest
        - (3) Succession in ponds and lakes
4. Distribution of living things
    - a. Types of geographic distribution
        - (1) Lateral distribution
        - (2) Vertical distribution
    - b. Barriers to dispersal
        - (1) Biotic barriers
        - (2) Climatic barriers
    - c. Major climatic zones of North America

        - (1) Tropical
        - (2) Semi-tropical
        - (3) Temperate
        - (4) Arctic
    - d. The biomes
        - (1) Coniferous forest
        - (2) Deciduous forest
        - (3) Grasslands
        - (4) Desert
        - (5) Rainforest
        - (6) Marine
        - (7) Fresh water
- 5. Man and conservation
    - a. Soil and water conservation
        - (1) Composition of soil
        - (2) Conservation of soil
            - (a) Crop rotation
            - (b) Contour cultivation
            - (c) Strip cropping
            - (d) Terracing
            - (e) Cover crops
            - (f) Soil binding plants
    - b. Water conservation
        - (1) Dams and water power projects
        - (2) Stream pollution

- c. Forest and wild life conservation
    - (1) Importance of forests
    - (2) Fire prevention
    - (3) Damage by disease, insects and other animals
    - (4) Reforestation
    - (5) Extinction of certain wild life
        - (a) Fish conservation
        - (b) Protection of birds
        - (c) Protection of furbearing animals
    - (6) Game laws
- d. Conservation of human life

E. Experiments and/or demonstrations

1. Effect of nitrogen fixing bacteria on plant growth
2. Effect of nitrates on growing plants
3. Types of animal and plant communities in the soil
4. Test various soils for capillarity
5. Germinate seedlings - check soil binding force
6. Waterholding ability of soils
7. Testing the acidity of soil
8. Action of ground water
9. Soils for plants
10. Observation of Insectivorous plants
11. Nitrogen-fixing bacteria and legumes
12. Termites and their protozoa
13. Examination of lichen
14. The mold as a saprophyte

15. Frogs and their parasites
16. Study of plankton
17. Construct a microaquarium
18. Prepare a balanced aquarium

F. Motivating activities:

1. Observe a natural succession
2. Observe and note the interdependence of living things in an area of your yard
3. Observe films on the activities of animals
4. Reconstruct the possible succession in an extensive wooded area
5. Construct food chains and food webs from producer to decomposer
6. Conduct soil tests

G. Enriching Activities:

1. Report on the American bison
2. Report on the carrier pigeon
3. Display with pictures, maps, and posters related to conservation
4. Read the "Dismal Theory" of Maltus
5. Read about biological clocks
6. Report on bird flyways

H. Teaching aids:

1. Sand table
2. Aquarium
3. Microscope
4. Field trips
    (a) Eroded area
    (b) Grassy area

(c) Forest area

(d) Swift running stream

(e) Slow moving stream

(f) Seashore

(g) Reforested area

(h) Watershed

(i) Vacant lots

5. Films:

a. Forest Grows 11' C JS EBF

b. Hibernation and other Rorms of Dormancy 11' B/W EJ EBF

c. High Artic Biome,The 22' C JS EBF

d. How Nature Protects Animals 11' C EJA EBF

e. Life in the Grasslands 11' C EJA EBF

f. Life in the Sea 11' C EJSA EBF

g. Man's Problem 19' C JSA EBF

h. Marine Biologist 14' B/W JS EBF

i. Marine Life 11' C EJ EBF

j. Nature's Plan (Living Water Service) 14' C JSA EBF

k. Population Ecology 19' C SCA EBF

l. Sea Zoo 10' B/W EJS Almanac

m. Seasons, The 10' B/W EJS United

n. Seeds of Destruction 10' C JSCA

o. Succession: From Sand Dunes to Forest 16' C JS EBF

p. Temperate Decidious Forest 16' C JS EBF

q. Trees for Tomorrow 18' B/W EJS United

r. Tropical Rain Forest 16' C JS EBF

s.	Undersea Life	8'	B/W	EJS	CN
t.	Water in the Air	11'	B/W	EJ	EBF
u.	Water Power	11'	B/W	JS	EBF
v.	What is Ecology	11'	C	JS	EBF
w.	Work of Rivers	11'	B/W	JS	EBF
x.	Work of Running Water	11'	B/W	JS	EBF
y.	Your Friend the Forest	6'	C	PE	EBF
z.	Your Friend the Soil	7'	C	PE	EBF
aa.	Your Friend the Water	6'	C	PE	EBF
bb.	Behavior of Animals and Plants	11'	C	JS	CN
cc.	Camoflage in Nature Through Pattern Matching	7½'	C	JS	CN
dd.	City Under Ice	15'	B/W	JS	Hearst
ee.	Community, The	11'	C	JS	EBF
ff.	Conservation of Natural Resources	11'	B/W	JS	EBF
gg.	Grasslands, The	17'	C	JS	EBF
hh.	Desert, The	22'	C	JS	EBF
ii.	Desert Nomads	20'	B/W	EJS	United
jj.	Erosion	6'	B/W	EJ	
kk.	Focus on Desalinization Fresh Water from the Sea	23'	B/W	JS	Hearst

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EXPLANATION FOR THE GENERAL CHEMISTRY GUIDELINE

The chemistry course should prepare those high school students whose purpose it is to continue the study of chemistry in college and to further in those students who will not continue the study of chemistry after high school an understanding of the importance of science in current and future human activities. The course materials for a general study in chemistry should be appropriate for all students who take chemistry. It is assumed that the great majority of these students are in the upper half of the national high school population with respect to academic ability.

The teaching of chemistry in the secondary school should not be committed to only one approach. There are two different approaches recently produced: Chemical BOND Approach and the CHEM Study Approach (financed by funds from National Science Foundation). The CBA stresses chemical bond as its theme--chemicals possess characteristic structures indicating a need for geometry. CHEM Study stresses experimental and laboratory approach. Both approaches have merits and disadvantages. Neither should be the ultimate in a chemistry curriculum; however, these programs should stimulate re-examination of individual programs.

By the time most students reach high school, they have been conditioned to the idea that the way to succeed (get good grades) is to take careful note of the facts which the teachers and textbooks indicate are significant, memorize the facts and produce them on an examination. Courses have typically stressed learning the definition of terms, and any laboratory work the student has performed or observed the teacher perform has likely been for the express purpose of "proving" what they have already "learned" through reading, lecture, and class discussion. The national trend in teaching all "science" is to stress principles and concepts using the laboratory to discover these, rather than merely confirm. It is believed, then, that students will come to a better understanding of the nature of scientific investigation and the uncertainties inherent in all scientific work. Facts would be taught as related to ideas. And finally, the competent teacher will glean the ideas from any approach that will best fit the particular teaching situation.

Chemistry

Purpose:

To familiarize the student with certain fundamental and theoretical concepts that have been proposed to explain the regularities in chemistry. To emphasize his independent discovery of the regularities and principles by utilizing the activities of science.

Suggested Overall Objectives for the teaching of Chemistry.

1. To develop an understanding of the fundamental nature of matter.
2. To develop a working knowlege of certain physical and chemical changes and the predictive value therein.
3. To provide varied experience in understanding analysis and synthesis.
4. To stress skill in laboratory techniques.
5. To require a responsible attitude in handling equipment and chemicals.
6. To transmit a feeling for the scientific process and implant the habit of use.
7. To develop appreciation of exact measurements and the importance of mathematics as a tool.
8. To enhance an understanding of the impact of chemistry on the culture and its relationship to family living, leisure time, standards of living, health and safety.
9. To increase awareness of the occupational possibilities related to chemistry.
10. To further develop a scientific vocabulary as it arises with a related experience.

11. To instill an appreciation for the research of great chemists.
12. To insure familiarity in locating and using source material.
13. To help in the acquisition of the attitudes characteristic of science, as intellectual curiosity, respect for differences of opinion, thoroughness, intellectual integrity and reliance on facts.

GENERAL CHEMISTRY

I. Introduction - Chemistry in a Modern World

A. Problems:

1. What is the science of chemistry?
2. What are the general classes of matter and its changes?

B. Objectives:

1. To give a general indication of the creative effort in chemistry put forth by scientists.
2. To develop an appreciation of the significance of chemistry and an understanding of what chemistry deals with: matter.
3. To provide the student with a working knowledge of some measurements necessary in understanding chemistry.

C. Principles and concepts:

1. The use of scientific methods is basic to the development of most scientific knowledge. (MC '62 pp 4)
    a. Natural laws
    b. Phases of scientific methods
    c. Importance of experiments
2. All materials about us consist of matter, however, it is more precisely described than defined. (MC '62 pp 6)
    a. Nature of inertia
    b. Measure of inertia
    c. Distinction between mass and weight
    d. Density
    e. States of matter
    f. Properties of matter

3. Energy is associated with matter but is not a form of matter (CBA pp 362-363)
    a. Forms of energy
    b. Conservation laws
4. The study of science could not be precise without a suitable system of measure. (MC '66 pp 11)
    a. Metric system
    b. Temperature and its measurement
    c. Heat and its measurement
5. The measurement of any physical quantity is subject to some uncertainty. (MC '66 pp 16)
    a. Meaning of accuracy
    b. Expression of accuracy
    c. Meaning of precision
    d. Expression of precision
    e. Significant figures
    f. Exponetial expression
    g. Operatinns with significant figures
    h. Operation with units
6. Organization and classifying of matter is pertinent to the study of matter and the saving of time and effort. (MC '62 pp 24)
    a. Mixtures
    b. Compounds
    c. Elements
    d. Relative scarcity of elements

      - e. Classification of elements
      - f. Significance of the symbol
      - g. Law of Definite Composition
    - 7. An understanding of the changes in matter is essential to the control of matter. (MC '62)
      - a. Physical changes
      - b. Chemical changes
      - c. Spontaneous reactions
      - d. Energy change in reactions
      - e. Entropy change in reactions
      - f. Nuclear changes

(3, Chapt. 1, 2, 3; 4 Chapt. 1, 2)

NOTE: A good review of mathematics appropriate in this unit can be found in CHEM Study Laboratory Manual, Appendixes 3, 4, 5 pp 109-120.

II. The Organization of Chemistry

- A. Problems:
  - 1. What is the structure of an atom?
  - 2. What evidence is there and what is the "model" for electron configuration of Atoms?
  - 3. What is the Periodic Law?
- B. Objectives:
  - 1. To establish a reasonable understanding of the atomic structure model and its tentativeness to revision through further experimentation.
  - 2. To develop some understanding of the importance of mathematics in developing the electron configuration model.

3. To help the student understand the Periodic table and its importance in chemistry.

C. Principles and Concepts:

1. The atomic theory implies that matter consists of discrete particles. (CBA pp 116)
    a. Ultimate particles of matter
    b. Dalton's contribution
    c. The atom
    d. Properties of atoms
2. Atoms are composed of several different kinds of particles arranged in a rather complex way. (MC '66 pp 42)
    a. Nucleus: protons and neutrons
    b. Shells of energy levels: electrons
    c. Atomic number
    d. Isotopes
    e. Mass number
    f. Atomic mass
3. The Avogadro number is an important and useful constant of measurement in chemistry. (MC '66 pp 48)
    a. Mole
    b. Gram-atomic weight
    c. Atomic weight
4. The location of an electron may be described by a "space orbital", which may be thought of as a highly probable location. (MC '66 pp 54)
    a. "Opposites attract" theory

b. Electromagnetic radiation: photon

c. Atomic spectra: excited atom, bright line spectrum

d. Wave mechanics: space orbital

(1) Principal quantum number

(2) Secondary quantum number

(3) Magnetic quantum number

(4) Spin quantum number

(5) Sublevel notation

(6) Electron-dot notation: pair, octet

(7) Orbital Notation

5. Electrons tend to enter various orbitals in a definite order starting with the lowest energy. (MC '66 pp 56)

a. Atoms of the first three series

b. Atoms of the fourth series

c. Atoms of the fifth series

d. Atoms of the sixth series

e. Atoms of the seventh series

6. The physical and chemical properties of the elements are periodic functions of their atomic numbers. (MC '66 pp 66)

a. Triads

b. Law of Octave

c. Periodic table - Mendeleyev

d. Atomic numbers

e. Periodic law

f. Modern periodic table

(1) Period or series

(2) Group or family

      (3) Transition elements
      (4) Rare earth elements
      (5) Metalloids
   g. Periodic properties
      (1) Atomic Radius
      (2) Ionization energy: Ion
      (3) Electron affinity

(1, Chapt 10; 2, Chapt 6, 15; 3, Chapt 4, 5, 6; 4 Chapt 3,4,5)

III. Chemical Formulas and Equations

A. Problems:

1. How do atoms combine?
2. What is the value in formula writing?
3. How is chemical action illustrated and for what purposes?

B. Objectives:

1. To develop an understanding of the concepts involved in chemical bonding and types of chemical bonds.
2. To develop an understanding of the formula and what it represents and the mathematical skills in problem solving.
3. To develop an understanding of the variety of facts represented by an equation and the skills involved in the use of the chemical equation.

C. Principles and Concepts:

1. The electrons in the outermost shell of an atom play a very active part in the formation of compounds. (MC '66 pp. 79)
   a. Valence electrons, kernel, noble gas structure
   b. Ionic bonding -- electrovalence

        - (1) Electron transfer
        - (2) Ion: cation, anion
        - (3) Empirical formula
        - (4) Energy changes
        - (5) Relative size of atoms and ions
    - c. Covalent bonding -- covalence
        - (1) Electron sharing
        - (2) Molecule
        - (3) Molecular formula
        - (4) Energy changes
- 2. Oxidation numbers are arbitrary values. (CBA pp. 101)
    - a. Oxidation state
    - b. Oxidation number
    - c. Oxidizing agent
    - d. Reducing agent
- 3. Atoms and molecules are units of structure. (CBA pp. 124)
    - a. Elements
        - (1) Free atoms -- monatomic molecules
        - (2) Diatomic and polyatomic molecules
        - (3) Giant molecules
    - b. Compounds
        - (1) Simple molecules
        - (2) Molecular aggregates
        - (3) Ions in crystal lattice
- 4. Atoms of different elements differ in their tendency to attract electrons. (CBA pp. 525)

- a. Electronegativity:
    - (1) Ionic bond: ions
    - (2) Polar covalent bond: polar molecule
    - (3) Covalent bond: nonpolar molecule
    - (4) Radicals

5. Combinations of the symbols for the elements in each particular compound are called formulas. (CBA pp. 99)
    - a. Formula writing
        - (1) Total positive and negative charge agreement
        - (2) Use of subscripts and parentheses
    - b. Compound naming
        - (1) Ion names
        - (2) Binary compound names
    - c. Significance of a chemical formula
        - (1) Composition of a chemical formula
        - (2) Formula weight -- molecular weight
        - (3) Percentage composition
        - (4) Empirical formula determination
        - (5) Molecular formula determination
    - d. Law of Definite Composition
    - e. Law of Multiple Proportions
    - f. The mole and mass quantities
        - (1) Gram-atomic weight
        - (2) Gram-molecular weight
        - (3) Gram-formula weight

6. Illustration of chemical action by a chemical equation has quantitative as well as qualitative significance. (MC '66 pp. 113-114)

- a. Word equation: qualitative significance
- b. Formula equation: quantitative significance
- c. Written equations
  - (1) Represent facts
  - (2) Include all symbols and formulas of reactants and products
  - (3) Satisfy the Law of Conservation of Atoms
- d. Balanced equations show
  - (1) Formula proportions
  - (2) Mole proportions
  - (3) Mass proportions
- e. Stoichiometry: chemical arithmetic
  - (1) Mass-mass problems
    - (a) Mole method
    - (b) Proportion method

(1, Chapt 3; 2 Chapt 2,3,13,16; 3 Chapt 6,11,12,13; 4 Chapt 6,78)

IV. The Physical States of Matter

A. Problems:

1. What are the physical states of matter?
2. What is the Kinetic Molecular Theory and of what use is it?

B. Objectives:

1. To develop an understanding of the Kinetic Molecular Theory and its use in explaining the physical states of matter.
2. To develop an understanding of how the processes of analysis and reasoning are employed in the solution of mathematical problems involving the physical states of matter.

C. Principles and Concepts:

1. The "Kinetic Theory" helps explain the properties of gases in terms of forces between the particles and energy they possess. (MC '66 pp. 125)
    a. Kinetic Theory
    b. Properties of gases
    c. Expansion
    d. Pressure
    e. Low density
    f. Diffusion
2. The kinetic theory describes an ideal gas. (MC '66 pp. 126)
3. There are attractive forces between gas molecules. (MC '66 pp. 154)
    a. Strength indicated by condensation temperatures
    b. Van der Waals forces
    c. Attraction between polar molecules
4. Cases spread out spontaneously to fill a space. (MC '66 pp. 128)
    a. Diffusion: Graham's Law
5. The volume of a gas depends on its temperature and pressure. (MC '66 pp. 134)
    a. STP
    b. Measuring gas volume and pressure: eudiometer: barometer
        (1) Over mercury: difference in levels
        (2) Over water: difference in levels; water vapor pressure
    c. Boyle's Law
    d. Kelvin temperature scale
    e. Charles' Law
    f. Combined Gas-Law formula
    g. Real gas behavior
6. Under certain conditions definite regularities characterize gases. (MC '66 pp. 134)
    a. Law of Combining Volumes of Gases
        (1) Gay-Lussac's Law
    b. Avogadro's Principle
        (1) Common Gases -- diatomic molecules
        (2) Noble gases -- monatomic molecules

- c. Specific gravity
- d. Molar volume
- e. Density of gas
- f. Experimental determination of molecular weight
- g. Gas volume-gas volume problems
- h. Mass-gas volume problems
  - (1) Solution by moles
  - (2) Solution by proportion
- i. Gases collected over water
- j. Ideal gas equation -- gas constant
- k. Real gases and ideal gases

7. The "Kinetic Theory" helps explain the properties of liquids in terms of forces between the particles of matter and the energy they possess. (CBA pp. 316-320)
   - a. General properties of liquids
     - (1) Definite volume
     - (2) Fluidity
     - (3) Noncompressibility
     - (4) Diffusion
     - (5) Evaporation
   - b. Specific gravity
   - c. Equilibrium -- physical equilibrium
     - (1) Equilibrium vapor pressure
     - (2) Le Chatelier's principle
   - d. Changes of state
     - (1) Boiling of liquids
       - (a) B. P.

        - (b) Molar heat of vaporization
    - (2) Liquefaction of gases
        - (a) Critical pressure
        - (b) Critical volume
        - (c) Critical temperature -- measure of molecular attraction

8. The "Kinetic Theory" helps explain the properties of solids in terms of forces between the particles of matter and the energy they possess. (CBA pp. 316-320)
    - a. General properties of solids
        - (1) Definite shape
        - (2) Definite volume
        - (3) Noncompressibility
        - (4) Very slow diffusion
        - (5) Crystal formation
    - b. Changes of state
        - (1) Freezing and melting
        - (2) Molar heat of fusion
        - (3) Sublimation
    - c. Amorphous solids
    - d. Crystalline solids
        - (1) Six crystal systems
        - (2) Types of lattice structure
            - (a) Ionic
            - (b) Covalent -- macromolecules
                - ((1)) Metallic -- electron gas
                - ((2)) Molecular

(References for 1-8: 1, Chapt 8; 2, Chapt 4,5; 3, Chapt 9,14,15;
4, Chapt 9,10,11)

9. Water is both the most abundant and the most useful liquid. (MC '62 pp. 148)
    a. Physical properties
    b. Molecular structure -- hydrogen bonding
    c. Use as a standard
    d. Chemical properties
        (1) Stability
        (2) Behavior with metals
        (3) Behavior with metallic oxides -- basic anhydride
        (4) Behavior with nonmetallic oxides -- acid anhydride
        (5) Water of crystallization -- hydrate, anhydrous compounds
        (6) Promotion of chemical reactions
    e. Efflorescence
    f. Deliquescence -- hygroscopic materials
    g. Deuterium oxide

(Reference for 9: 1, Chapt 18; 3, Chapt 10; 4, Chapt 11)

V. Solutions and suspensions
  A. Problems:
    1. What are solutions and suspensions, their fundamental differences and their significance to man?
  B. Objectives:
    1. To develop an understanding of the broad generalization and laws which apply to solution and suspension phenomena.
    2. To train students in the fundamental skills - making, measuring, handling and mathematical measurement - related to further understanding solution and suspensions.

3. To apply concepts of the structure of compounds and crystals to explanations of solution and suspension phenomena.

C. Principles and concepts:

1. A substance that is homogeneous with respect to subdivision but heterogeneous with respect to change in physical state is called a solution. (CBA pp. 25)
    a. Nature of solutions
        (1) Solute
        (2) Solvent
        (3) Nonelectrolyte
        (4) Types of solutions
2. The solution process is reversible.(MC '66 pp. 184)
    a. Solution equilibrium
    b. Saturated solution
    c. Pressure and solubility
    d. Henry's Law
    e. Temperature and solubility
3. The dissolving process, represents competition between the interaction of solution particles and involves energy. (CBA pp. 574)
    a. Dissolving actions that require energy
    b. Dissolving actions that yield energy
    c. Net actions that are exothermic
    d. The role of entropy
4. The difference between the heat content of a solution and the heat contents of its components is called heat of solution (MC '66 pp. 190)

  - a. Meaning of positive values
  - b. Meaning of negative values
  - c. Heat of solution - change in solubility with temperature relationship
  - d. Le Chatelier principle explanation
  - e. Increasing the rate of dissolving
  - f. Dilute and concentrated solutions

5. Concentration of solutions refer to the relative amounts of components (CHEM. pp. 72)
  - a. Molality
  - b. Selectivity of solvents
  - c. Solvation and hydration
  - d. The hydrogen bond
  - e. Molal freezing-point depression
  - f. Molal boiling-point elevation
  - g. Determination of molecular weights

6. Some substances, like NaCl(s) and HCl(g), dissolve in water to form conducting solutions (CHEM. pp. 169)
  - a. Electrolytes
    - (1) Method of testing
    - (2) Comparisons with nonelectrolytes

7. The theory of ionization assumes: that electrolytes in solution exist in the form of ions; that an ion is an atom or group of atoms which carries an electric charge;

that the water solution of an electrolyte contains an equal number of positive and negative charges. (MC '66 pp. 204)

   a. Structure of electrolytes

8. The interaction of ions with water is called hydration. (CBA pp. 575)

   a. Hydration of ions

      (1) Dissociation process

      (2) Ionization process

      (3) Weak electrolyte

      (4) Ionization in water

      (5) Substances that do not ionize

9. The solute particle-to-solvent molecule ratio have a distinct relationship to the variable properties of solutions. (MC '66 pp. 210)

   a. Effect on freezing and boiling points

   b. Measuring degree of ionization

   c. Electrolysis of water

10. There are three acid-base theories in current use because each can be applied with benefit to appropriate systems. (CBA pp. 675)

   a. Nature of acids

      (1) Ionization of strong mineral acids

      (2) Arrhenius' explanation of an acid

      (3) Brønsted acid

    (4) Proton donor in nonaqueous solution
    (5) Properties of acids
    (6) Monoprotic, diprotic, triprotic acids
    (7) Naming traditional acids
    (8) Acid anhydride reactions

b. Nature of bases

    (1) Brønsted base
    (2) Properties of hydroxide compounds
    (3) Amphiprotism
    (4) Basic anhydride reactions
    (5) Formulas of acid and bases
    (6) Relative strengths of acid and bases
    (7) Conjugate acid-base pair
    (8) Comparison of the three theories: Arrhenius, Brønsted-Lowry and Lewis

c. Concentration of solutions

    (1) Molar solutions
    (2) Gram-equivalent
    (3) Normal solutions
    (4) Autoprotolysis
    (5) Ion concentrations in water
    (6) Meaning of pH
    (7) Calculations involving pH
    (8) Acid-base titration

(9) Titration calculations

(10) Indicators in titration

(11) Indicators for pH measurement

11. Ionic compounds are referred to as salts. (CBA pp. 504)

a. Nature of salts

(1) Examples of salt producing reactions

(2) Name salts by stock system

12. Suspensions are determined by the state of subdivision rather than the chemical nature of a material. (MC '66 pp. 241)

a. The colloidal state

(1) Suspension vs. solutions

(2) Range of colloidal size

(3) Types of colloidal suspension

b. Surface Chemistry

(1) Effect of subdivision

(2) Adsorption

(3) Hydrogen electrode

(4) Contact agents

(5) Catalytic poisons

c. Suspensoids

(1) Hydrosol

(2) Aersol

(3) Brownian movement

      - (4) Tyndall effect
      - (5) Preparation of suspensoids
      - (6) Protective colloid
      - (7) Precipitation of suspensoids
      - (8) Flotation
    - d. Emulsoids
      - (1) Stabilizing factors
      - (2) Fibril network
      - (3) Biocolloids

(1, Chapt. 13, 16; 2, Chapt. 9, 10, 11; 3, Chapt. 19-23, 32, 33; 4, Chapt. 12-15)

VI. Carbon and its Compounds

- A. Problems:
  - 1. What is organic chemistry and why is it a separate branch of chemistry?
  - 2. What are some of the scientific and social implications that can be drawn from some of the achievements in organic chemistry?
- B. Objectives:
  - 1. To develop an understanding of organic chemistry and the related conceptual aspects such as dependence of properties on structure, allotropism, resonance, hybrid bonds,

destructive distillation and incomplete combustion.

2. To apply theories of atomic structure and bond formation in developing an understanding of allotropes and the multiplicity of carbons.
3. To develop respectful attitudes toward organic chemistry by drawing out the social and economic aspects.

C. Principles and Concepts:

1. In abundance, carbon ranks eleventh by weight among the elements in the earth's crust. In importance, it ranks far higher than this. (MC '66 pp. 268) CBA ranks it 12th.
2. Organic chemistry includes the study of carbon compounds whether or not they are produced by living organisms. (MC '62 pp. 222)
3. The model for the carbon atom implies that the four outer electrons are arranged tetrahedrally. (CBA pp. 253 and MC '62 pp. 223)
    a. Carbon atom structure - hybridization
    b. Forms of carbon - allotropy
        (1) Diamond
        (2) Graphite - electric furnace, resonance
        (3) Charcoal - destructive distillation, activation
        (4) Coke
        (5) Boneblack and lampblack
        (6) Carbon black, gas carbon, petroleum coke

4. Carbon atoms may form covalent bonds with other elements. (MC '62 pp. 230)
    - a. Carbon dioxide
        - (1) Occurance
        - (2) Preparations
            - (a) Industrial
            - (b) Laboratory
            - (c) Natural
        - (3) Molecular structure
        - (4) Properties
            - (a) Physical
            - (b) Chemical
        - (5) Uses
    - b. Carbon monoxide
        - (1) Occurance
        - (2) Preparations
            - (a) Industrial
            - (b) Laboratory
        - (3) Molecular structure
        - (4) Properties
            - (a) Physical
            - (b) Chemical
        - (5) Uses
        - (6) Physiological action

5. Carbon atoms may form covalent bonds with other elements, or with other carbon atoms: the carbon atoms may link together in chains and rings. (MC pp. 230)
    - a. Hydrocarbons
        - (1) Reasons for existence of so many carbon compounds
            - (a) Carbon atoms bond covalently
            - (b) Isomers
        - (2) Structural formula
        - (3) Organic and inorganic compounds differ
            - (a) Solubility in water
            - (b) Ease of decomposition
            - (c) Reaction rates
            - (d) Type of bonding
        - (4) Alkanes - saturated, homologous series
            - (a) Preparations - fractional distillation
            - (b) Reactions - combustion, substitution
        - (5) Alkenes - unsaturated
            - (a) Preparations - cracking
            - (b) Reactions - addition, polymerization, combustion
        - (6) Alkynes
            - (a) Preparations
            - (b) Reactions
        - (7) Alkadienes

- (8) Aromatic hydrocarbons
    - (a) Reactions - halogenation, nitration, sulfonation, Friedel-Crafts reaction
- (9) Other aromatic hydrocarbons

b. Rubber

- (1) Coagulation
- (2) Compounding
- (3) Vulcanization
- (4) Accelerator
- (5) Anti-oxidant
- (6) Neoprene
- (7) SBR
- (8) Butyl rubber
- (9) Nitrile rubber
- (10) Polyisoprene

c. Hydrocarbon substitution products

- (1) Halogen substitution products
    - (a) Preparations
    - (b) Reactions - Grignard reagent
- (2) Alcohols
    - (a) Preparations - fermentation, denatured alcohol
    - (b) Reactions - sulfonation
- (3) Ethers - Williamson synthesis
- (4) Aldehydes

- (a) Preparations
- (b) Reactions - Fehling's test, aldol condensation, phenylhydrozones

(5) Ketones
  - (a) Preparations
  - (b) Reactions

(6) Carboxylic acids and esters
  - (a) Preparations
  - (b) Reactions - esterification, saponification

(7) Amines - primary, secondary, tertiary
  - (a) Preparations
  - (b) Reactions

(8) Amides
  - (a) Preparations
  - (b) Reactions - nylon

(9) Nitriles
  - (a) Acrytonitrile
  - (b) Acrylic fibers

d. Natural organic compounds

(1) Fats - lipids
  - (a) Chemical nature - esters
    - 1) Fats and oils
    - 2) Rule of even distribution
  - (b) Reactions

            1) Hydrolysis
            2) Saponification
            3) Hydrogenation
- (2) Carbohydrates
    - (a) Chemical nature - polyhydroxyaldehydes or polyhydroxyketones
    - (b) Monosaccharides
        - 1) Glucose
        - 2) Fructose
        - 3) Galactose
    - (c) Disaccharides
        - 1) Sucrose
        - 2) Maltose
        - 3) Lactose
    - (d) Polysaccharides
        - 1) Starch
        - 2) Glycogen
        - 3) Cellulose
        - 4) Modified cellulose
            - a) Vicose process
            - b) Cellulose acetate
            - c) Cellulose nitrate
- (3) Proteins
    - (a) Chemical nature - complex amides

- (b) Amino acids
- (c) Peptides - peptide linkage
- (d) Simple and conjugated proteins
- (e) Reactions
  - 1) Xanthoproteic reaction
  - 2) Biuret reaction
  - 3) Precipitation
  - 4) Heat coagulation
  - 5) Hydrolysis
- (f) Structure
  - 1) Fibrous
  - 2) Globular
  - 3) Amino acid sequence

(1, pp. 264-266, 739-742; 2, Chapt. 18, 24; 3, Chapt. 16, 17, 18, 42, 44; 4, Chapt. 16-19)

VII. Chemical Reactions

- A. Problems:
  - 1. What are the variety of facts and concepts represented by chemical reactions?
  - 2. Why do chemists write equations?
- B. Objectives:
  - 1. To develop further an understanding of the variety of facts

and concepts represented by chemical reactions such as energy changes, reversibility and oxidation-reduction.

2. To guide students to discover some of the laws and principles involved through experimentation and application of facts.
3. To develop further skills in writing equations, applying rules to balancing redox reactions, mathematical determinations involving reactions.

C. Principles and Concepts:

1. In most chemical actions the energy change can be measured in terms of the heat released or absorbed during the reaction. (MC '66 pp. 332)
    a. Heat of reaction
    b. Heat of formation
    c. Meaning of negative values for delta H
    d. Meaning of positive values for delta H
    e. Relationship of stability to heat of formation
    f. Heat of combustion
    g. Thermochemical equations
2. The "driving force" of reactions involves reaction mechanism and reaction kinetics and the energy changes. (MC '66 Chapt. 20 pp. 332-351)
    a. Energy change
    b. Entropy change

    c. Free-energy change

3. The difference between the least kinetic energy needed for reaction to occur and the average kinetic energy of all collisions in the same system of molecules is known as the "activation energy."
   (CBA pp. 704)
    a. Potential energy barrier
    b. Collision theory
    c. Activation complex
    d. Reaction mechanisms
4. Reactions proceed at different rates. (CHEM pp. 124)
    a. Influency factors
    b. Rate determining step
    c. Alternate path of reaction
    d. Law of Mass Action
5. The equilibrium state of a chemical system exhibits a complex of characteristics. (CBA pp. 638)
    a. Reversibility of reactions
    b. Driving force considerations
    c. Reaction rate considerations
    d. Conditions of equilibirum
6. The equilibrium constant describes a chemical system in its equilibrium state. (CBA pp. 643)
    a. The equilibrium constant

   - b. Importance to chemist
   - c. General form of expression
   - d. The Hg-I_2-HI equilibrium system

7. In a system at equilibrium, any change which alters the rate of either reaction disturbs the equilibrium. (MC '66 pp. 359)
   - a. Le Chatelier's principle
   - b. Effects of concentration
   - c. Effects of pressure
   - d. Effects of temperature
   - e. End reactions
   - f. Common-ion effect
8. The equilibrium constant for certain systems expresses the equilibrium ratio of ions to molecules. (MC '66 pp. 365)
   - a. Ionization constants
   - b. Weak acid
   - c. Water
9. Hydrolysis is an acid-base reaction between water and an ion of a dissolved salt. (MC '66 pp. 369)
   - a. Basic anion hydrolysis
   - b. Acid cation hydrolysis
10. Solubility is a special case of equilibrium. (CHEM pp. 163)
    - a. Solubility product constant
    - b. Applications in solubility

- c. Applications in precipitation

11. Oxidation-reduction is descriptive of some reactions; there is no single operational definition of an oxidation-reduction reaction. (CBA pp. 584)
    - a. Oxidation and reduction processes
    - b. Oxidation states
    - c. Assigning oxidation numbers
    - d. Oxidation number and shared electrons
    - e. Balancing oxidation-reduction reactions
        - (1) Meaning of conservation of electrons
        - (2) Meaning of balancing electron shift
    - f. Oxidizing and reducing agents
        - (1) Characteristics of strong reducing agents
        - (2) Characteristics of strong oxidizing agents
        - (3) Relative strengths of oxidizing and reducing agents
        - (4) Interpretation of relative strengths table
        - (5) Determining gram-equivalents in redox reactions
    - g. Electrochemical reactions
        - (1) Spontaneous reactions
        - (2) Applications of electrochemical cells
        - (3) Driven reactions
        - (4) Applications of electrolytic cells
        - (5) The storage battery as a reversible cell
        - (6) Reactions of the discharge cycle

        - (7) Reactions of the charge cycle
    - h. Oxidation potentials
        - (1) Half cell reactions
        - (2) Oxidation potentials of half cells
        - (3) Standard hydrogen reference electrode
        - (4) Interpretations of standard oxidation potentials

(1, Chapt. 13, 15, 17; 2, Chapt. 7, 8, 9, 12; 3, Chapt. 22, 23; 4, Chapt. 20-22)

VIII. A Typical Period of Elements

- A. Problems:
    - 1. Why are the properties of the elements of Period Three what they are?
    - 2. How can some of the basic concepts, previously covered, be applied?
- B. Objectives:
    - 1. To apply some of the basic concepts to some specific elements of the table; concepts such as the three states of matter, electronic structure, oxidation-reduction, acid-base theory, chemical bonding.
    - 2. To show that changes across a row are large changes--changes of kind, for example, bonding in a row changes from metallic to covalent.

3. To help the student see how predictions can be made.
4. To develop appreciation for the role of chemical processes in producing natural wonders as well as materials for daily living.

C. Principles and Concepts:

1. There is an enormous difference between the behavior of elements on the left side of the periodic table and those on the right. (CHEM pp. 364)
    a. General appearance of Period Three elements
        (1) Metal
        (2) Metalloid
        (3) Non-metal
        (4) Noble gas
    b. Physical properties
        (1) Physical state
        (2) Crystalline or molecular structure
        (3) Binding forces
        (4) Density
        (5) Hardness
        (6) Conductivity of heat and electricity
        (7) Ductibility
        (8) Malleability
    c. Chemical properties
        (1) Electron configuration

        - (2) Ionization energy
        - (3). Oxidation states
        - (4) Atomic radius
    - d. Properties of oxides of Period Three elements
        - (1) Preparation of oxide
        - (2) Structure of oxide
        - (3) Reaction of oxide with water
    - e. Properties of hydrides
        - (1) Preparation of hydride
        - (2) Structure of hydride
        - (3) Reaction of hydride with water

(1, pp. 421-430; 2, Chapt. 20; 4, Chapt. 23)

IX. The Highly Electropositive Elements, Group I and II

- A. Problems:
    - 1. What are the similarities and differences among Group I and Group II elements?
    - 2. What are some of the important processes in the production of Group I and II elements?
    - 3. What are some of the important uses of these elements?
- B. Objectives:
    - 1. To develop an understanding of Group I and II elements by applying conceptual aspects already studied such as

dependence of properties on structure.

2. To further the importance and application of the scientific method by relating to the techniques used in the refining and production of Group I and II elements and their compounds.
3. To further the appreciation for the role of chemical processes in solving problems and producing materials related to daily living.
4. To continue development of fundamental skills: equation writing and mathematical calculations.

C. Principles and Concepts:

1. Though the elements in a family display similar chemistry, there are important differences as well. Many of these differences are explainable in terms of atomic size. (CHEM Study pp. 377)
    a. Group I elements
        (1) General properties
        (2) Crystal structure
        (3) Ionization potentials
    b. Members
        (1) Lithium
            (a) Occurrence and discovery of lithium
            (b) Uses of lithium
            (c) Unusual properties
            (d) Identification test

        - (e) Compounds of lithium
    - (2) Sodium
        - (a) Occurrence
        - (b) Discovery and preparation
        - (c) Properties
        - (d) Uses
        - (e) Sodium chloride; properties and uses
        - (f) Sodium hydroxide; properties and uses
        - (g) Solvay process
        - (h) Other compounds of sodium
    - (3) Potassium
        - (a) Occurrence
        - (b) Discovery and preparation
        - (c) Properties
        - (d) Compounds
    - (4) Rubidium, Cesium, and Francium
        - (a) Discovery and uses
    - (5) Spectroscopy
        - (a) Description and use of spectroscope
        - (b) Origin of spectral lines
- c. Group II elements: The Calcium Family
    - (1) General properties of Group II elements
    - (2) Ionic nature of Group II elements
    - (3) Oxides and hydroxides of calcium family

d. Members
- (1) Beryllium
    - (a) Preparation and properties
    - (b) Uses
- (2) Magnesium
    - (a) Occurrence
    - (b) Extraction of magnesium from sea water
    - (c) Extraction of magnesium from magnesium oxide
    - (d) Properties of magnesium
    - (e) Uses of magnesium and magnesium alloys
- (3) Calcium
    - (a) Occurrence
    - (b) Preparation
    - (c) Properties and uses
    - (d) Test for calcium
    - (e) Calcium carbonate
    - (f) Hard water: causes and types
    - (g) Methods of softening hard water
    - (h) Preparation and uses of calcium oxide
    - (i) Preparation and uses of calcium hydroxide
    - (j) Occurrence and uses of calcium sulfate
- (4) Strontium and barium
    - (a) Compounds of strontium
    - (b) Test for strontium

(c) Compounds of barium: occurrence and uses

(1, Chapt. 11; 2, Chapt. 21; 3, 4, Chapt. 24, 25)

X. Elements of the Central Region: Fourth-Row Transition Elements, Aluminum and the Metalloids

A. Problems:

1. What are the "transition elements": similarities, differences, and importance?

B. Objectives:

1. To continue to apply previously studied principles and concepts such as principles of electron configuration to d orbitals, dependence of properties on structure, chemical behavior in terms of oxidation-reduction, etc.
2. To develop further an understanding of some complex ions and compounds in terms of geometry, bonding, and reactions.
3. To continue to develop appreciation for the role of chemical processes in producing natural wonders as well as materials for daily living.
4. To continue to practice fundamental skills and the scientific method.

C. Principles and Concepts:

1. The term "transition element" remains mostly a useful way of designating elements in the middle region of the Periodic

Table. (CHEM Study, pp. 387)

a. Transition subgroups of the Periodic Table
    (1) Inner building of d sublevels
    (2) Inner building of f sublevels
    (3) General properties of transition elements
        (a) Metallic character
        (b) Oxidation states
        (c) Color
    (4) Complex ions and solubility
    (5) Paramagnetism

b. The Iron Family
    (1) Members of the iron family
    (2) Sources of iron
    (3) Recovery of iron from its ores
    (4) Steel Production
        (a) Open-hearth process
        (b) Electric furnace process
        (c) Basic-oxygen process
        (d) Vacuum degassing
    (5) Purity of iron
    (6) Three oxides of iron
    (7) Reactions of the Fe^{++} ion
    (8) Reactions of the Fe^{+++} ions
    (9) Tests for Fe^{++} and Fe^{+++} ions

d. Cobalt
    (1) Occurrence: ores of cobalt
    (2) Compounds of cobalt
    (3) Cobalt nitrate tests

e. Nickel
    (1) Properties of nickel
    (2) Compounds of nickel

f. The Copper Family
    (1) Members of the copper family
    (2) Compounds and recovery of copper
    (3) Electrolytic refinement of copper
    (4) Properties of copper
    (5) Tests for Cu++ ion
    (6) Silver: its occurrence and recovery
    (7) Properties of silver
    (8) Test for silver ion
    (9) Gold: occurrence and recovery
    (10) Properties and uses of gold
    (11) Gold compounds

g. The Zinc Subgroup
    (1) Members of the Zinc Subgroup
    (2) Zinc: recovery from its ores
    (3) Properties and uses of zinc
    (4) Cobalt nitrate tests

    - (5) Cadmium and its uses
    - (6) Mercury and its uses
    - (7) Compounds of mercury
    - (8) Tests for Hg_2^{++} ion

2. There are some elements that resemble metals in some characteristics and resemble nonmetals in others. These are referred to as metalloids. (CBA pp. 495)
    - a. The metalloid elements
        - (1) Periodic order of the metalloids
        - (2) Relation of aluminum to the metalloids
        - (3) Properties of the metalloids
    - b. Aluminum
        - (1) Periodic relation of aluminum to other light metals
        - (2) Occurrence
        - (3) Discovery
        - (4) Recovery
        - (5) Properties and uses
        - (6) Thermite process
        - (7) Thermite welding
        - (8) Compounds of aluminum
            - (a) Aluminum oxide
            - (b) Aluminum hydroxide
            - (c) Double salts of aluminum
            - (d) Silicates of aluminum

c. Boron
    (1) Boron as a metalloid
    (2) Recovery of boron
    (3) Compounds of boron
    (4) Borax bead tests

d. Silicon
    (1) Silicon as a metalloid
    (2) Silicon and its compounds
    (3) Silicones
    (4) Manufacture of glass

e. Arsenic
    (1) Recovery of arsenic
    (2) Properties and uses of arsenic

f. Antimony
    (1) Recovery of antimony
    (2) Properties and uses of antimony

(1, Chapt. 11; 2, Chapt. 22, 23; 3, Chapt. 31-37; 4, Chapt. 26, 27)

XI. The Highly Electronegative Elements

A. Problems:

1. What is nitrogen and its importance?
2. What is sulfur and its importance?
3. What are the Halogens: similarities, differences,

and importance?

B. Objectives:

1. To provide the opportunity for reinforcement and application of some already studied concepts: for example, acid strength as related to oxidation number.
2. To stress the utility of the mole and manipulation of units in the solution of many different kinds of quantitative chemical problems: continue balancing equations.
3. To continue to develop appreciation for the role of chemical processes in producing natural wonders as well as materials for daily living.

C. Principles and Concepts:

1. It is difficult to make nitrogen unite with other elements and its compounds are not very stable. (MC '62 pp. 448)
    a. Nitrogen
        (1) Occurrence of nitrogen
        (2) Discovery of nitrogen
        (3) Preparation of nitrogen
            (a) By fractional distillation of liquid air
            (b) By decomposing ammonium nitrate
        (4) Physical properties
        (5) Chemical properties
        (6) Uses of elementary nitrogen
        (7) Test for nitrogen

- (8) Nitrogen fixation
    - (a) Natural method
    - (b) Artificial method
- b. Ammonia and ammonium compounds
    - (1) Occurrence of ammonia
    - (2) Preparation of ammonia
        - (a) By decomposing ammonium compounds
        - (b) By destructive distillation of bituminous coal
        - (c) By the Haber process
    - (3) Physical properties of ammonia
    - (4) Chemical properties of ammonia
    - (5) Uses of ammonia and ammonium compounds
    - (6) Hydrazine: uses
- c. Nitric acid
    - (1) Preparation of nitric acid
        - (a) From nitrates
        - (b) From ammonia: Ostwald process
    - (2) Physical properties of nitric acid
    - (3) Chemical properties of nitric acid
    - (4) Test for a nitrate
    - (5) Uses of nitric acid

2. Sulfur occurs both free and combined. (MC '62 pp. 409)
   (CHEM Study, Chapt. 13 can be substituted)
    - a. Sulfur

- (1) Occurrence
- (2) Mining - Frasch process
- (3) Physical properties
- (4) Allotropic forms: solid and liquid
- (5) Chemical properties
- (6) Uses

b. Hydrogen sulfide

- (1) Occurrence
- (2) Preparation
- (3) Physical properties
- (4) Chemical properties--relationship of (S=) and (H_3O+) in H_2S solutions
- (5) Test for sulfide
- (6) Uses of hydrogen sulfide--sulfide precipitation

c. Other sulfides

- (1) Metallic sulfides
- (2) Carbon disulfide

d. Oxides of sulfur

- (1) Occurrence of sulfur dioxide
- (2) Preparation of sulfur dioxide
- (3) Physical properties of sulfur dioxide
- (4) Chemical properties of sulfur dioxide
- (5) Uses for sulfur dioxide and sulfurous acid

e. Sulfuric acid

    - (1) Preparation
    - (2) Physical properties
    - (3) Chemical properties: acid, oxidizing and dehydrating
    - (4) Importance of some sulfates
    - (5) Test for a sulfate

3. The halogens are a family of elements that show some remarkable similarities and some interesting trends in chemical behavior. (CHEM Study pp. 352) (CHEM Study, Chapt. 19 can be substituted)

   Halogen family: general characteristics

   a. Fluorine
      - (1) Preparation
      - (2) Properties
      - (3) Usefulness of fluorine compounds
      - (4) Preparation and properties of hydrogen fluoride
      - (5) Uses of hydrofluoric acid

   b. Chlorine
      - (1) Occurrence of compounds
      - (2) Preparation of chlorine
      - (3) Physical properties
      - (4) Chemical properties
      - (5) Uses of chlorine
      - (6) Preparation, properties and uses of hydrogen chloride
      - (7) Abundance of chlorides

(8) Test for chlorides

c. Bromine

(1) Occurrence and discovery

(2) Bromine from bromides

(3) Physical properties

(4) Chemical properties

(5) Uses of bromides

(6) Test for soluble bromide

d. Iodine

(1) Discovery and occurrence

(2) Preparation

(3) Physical properties

(4) Chemical properties

(5) Uses

(6) Uses of iodides

(7) Test for soluble iodides

(1, pp. 433; 2, Chapt. 13, 19; 3, Chapt. 26, 27, 28, 30; 4, Chapt. 28-30)

XII. Nuclear Reactions: Radioactivity

A. Problem:

1. What is radioactivity?

B. Objectives:

1. To develop some understanding of the magnitude of nuclear

reaction energy: neutron/proton ratio and its importance, nuclear binding energy, and types of radioactivity.

2. To develop some understanding of Einstein's Law and its verification.
3. To acquire some skill in writing nuclear equations.
4. To acquire some knowledge of the destructive effects of nuclear weapons: nuclear investigations and possible dangers to world populations as a result of fallout.

C. Principles and Concepts:

1. Radioactivity is the spontaneous, uncontrollable decay of the nucleus of an atom with the emission of particles and rays. (MC '62 pp. 675)
    a. Natural radioactivity
        (1) Discovery of radioactivity
        (2) Discovery of radium
        (3) Sources of radium
        (4) Properties of radium
        (5) Other radioactive elements
        (6) Nature of radioactivity
        (7) Decay of atoms of radioactive elements
        (8) A series of radioactive elements
        (9) Applications of natural radioactivity
    b. Artificial radioactivity
        (1) Stability of a nucleus: binding energy,

proton/neutron ratio

(2) Types of radioactivity

(3) Nuclear energy

(4) Verification of Einstein's equation

(5) Nuclear reactions

(2, pp. 120-121, 416-419; 3, Chapt. 38, 39; 4, Chapt. 31)

Bibliography:

1. Chemical Systems, The Chemical Bond Approach Committee, 1963.

2. Chemistry--An Experimental Science, The Chemical Education Material Study, 1963.

3. Dull, et al., Modern Chemistry, 1962

4. Metcalfe, et al., Modern Chemistry, 1966

Teaching Aids:

Films

CHEM Study Films

Stock No.	Film Title	Guideline unit for which film can be used
4124	Equilibrium	7
4112	Chemical Families	2
4157	Chemical Bonding	3
4133	Electrochemical Cells	7
4106	Gas Pressure and Molecular Collisions	4
4148	The Hydrogen Atom (Std. Version)	4
4154	Shapes & Polarities of Molecules	4
4103	Gases & How They Combine	4
4121	Introduction to Reaction Kinetics	7
4151	Ionization Energy	2
4127	Catalysis	7
4130	Acid-Base Indicators	5
4142	Molecular Spectroscopy	9
4115	Molecular Motions	4
4139	Crystals & Their Structures	4
4118	Vibration of Molecules	4
4136	Nitric Acid	11
4163	Synthesis of an Organic Compound	6
4166	Mechanism of an Organic Reaction	6
4169	Bromine--Element from the Sea	11
4109	Electric Interactions in Chemistry	2
4160	A Research Prob: Inert(?) Gas Compounds	2
4178	Transuranium Elements	12
4149	The H-Atom (advanced version)	2
4181	Biochemistry & Molecular Structure	6
4175	High Temperature Research	10
4172	Vanadium--A Transition Element	10

Supplementary Materials and Comments:

1. (a) Chemistry--An Experimental Science Laboratory Manual, Chemical Education Material Study, W. H. Freeman and Co., San Francisco, 1963.

   Comment: Some of these experiments can be coordinated with the guideline units according to CHEM Study reference chapters for that unit. Also, reference has already been made to the appendices which provides a concise, compact review of exponential expressions, signed numbers, etc. It can be obtained from book depository for $1.20.

   (b) Chemistry--An Experimental Science text.

   (c) Chemistry--An Experimental Science Teachers Guide.

   Comment: This is one of the most comprehensive and most helpful guides especially for the teacher who is concerned with methods of teaching the scientific processes. The description of the teacher's role in carrying out experiments and the "background" sections could be of great value no matter what approach you use.

2. Investigating Chemical Systems Laboratory Manual, The Chemical Bond Approach Committee, 1963.

   Comment: Some of these experiments can be utilized with the guideline units according to CBA reference chapters for that unit. CBA Teacher's Guide and text would be of great value to the teacher.

3. Laboratory Experiments with Radioisotopes (for H. S. Science Demonstrations), Samuel Schenberg, U. S. Atomic Energy Commission, July, 1958.

Comment: The demonstrations in this manual (59 pages) may be adapted to the present syllabi in biology, chemistry, earth science, and physics. The book can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 35¢.

4. Laboratory Experiments in Chemistry, Metcalfe, Williams and Castka; Holt, Rinehart and Winston, Inc., 1966.

   Comment: This book contains the experiments in the 1962 "Modern Chemistry" laboratory manual, but they have been reorganized to provide varying degrees of challenge so that the student is involved in a scientific inquiry and real experimentation. Many of these experiments are of the open-ended type. There are twenty-six new experiments. This makes the 1962 "Modern Chemistry" laboratory manual look "dead."

5. (a) Scientific Experiments in Chemistry, Elbert C. Weaver, Manufacturing Chemists' Association; Holt, Rinehart and Winston, Inc., N. Y., 1966.

   (b) Scientific Experiments in Chemistry (Teacher's Manual), same as (a).

   Comment: These are experiments of the open-ended type. They can be used as a full year's course and can be correlated with all the guideline units. This is a "must" set.

GENERAL PHYSICS

Purpose:

To acquaint the student with certain fundamental phenomena related to matter and energy in the universe and to correlate these with mathematics using inductive reasoning and scientific modes of thinking.

Suggested Overall Objectives:

1. To develop an appreciation for the contributions of physics to the advancement of mankind.
2. To promote understanding of the natural laws that govern the universe.
3. To develop an understanding of the relationship between matter and the various forms of energy.
4. To acquire skill in accurately interpreting charts, graphs, tables, and other scientific data.
5. To develop the ability to clearly communicate understanding of concepts and principles in both oral and written form.
6. To develop precision in manipulating apparatus; and accuracy in observing, measuring, and recording.
7. To develop competencies which will enable the student to fill the need for scientific manpower.
8. To demonstrate the understandings, attitudes, abilities, interests, and skills necessary for successful participation in advanced studies in physics.

9. To develop an understanding of the orderliness of physical phenomena.
10. To develop interest in individual research and experimentation.
11. To recognize the desire to strive for excellence.

I. Introduction and measurements

- A. Problem: What is physics?
- B. Objectives:
    1. Developing a broader appreciation for the importance of physics.
    2. Furthering an understanding of the properties of matter and energy.
    3. Broadening the understanding of the concepts of volume, weight, mass, inertia, time.
    4. Understanding the importance of quantitative measurements.
- C. Principles and Concepts:
    1. Physics is the study of matter and energy.
    2. Matter and energy are interchangeable; the total amount of energy and matter in the universe is constant.
    3. Physics is a science which makes use of precise measurement.
    4. Matter and energy have many varying properties or characteristics.
- D. Topics:
    1. Physics as a fundamental science
    2. Matter and its properties
    3. Energy and its properties
    4. Relation of matter and energy
    5. Systems of measurement
        - a. Metric absolute system
        - b. English gravitational system

6. Units in the MKS, CGS, and FPS systems.
7. Significant figures.
8. Scientific notations
9. Orders of magnitude
    a. Orders of magnitude of time
    b. Orders of magnitude of distance

E. Motivating activities:

1. Show the class an irregular object such as a piece of metal or wood. Have students suggest ways to find the volume, weight, etc. (all properties of matter). This stimulates curiosity, provides motivation, and activates the thinking processes.

F. Experiments and/or demonstrations:

1. Experiment: Measurement of length
2. Experiment: Volume measurement
3. Experiment: Mass density of a solid

G. Enrichment Activities:

1. Devise an experiment to determine the time interval between the moment a bottle of perfume is opened at a distant point and the moment you smell it.
2. Report on the historical development of the metric system.
3. Report on how a stroboscope can be used to measure a short interval of time. Build or assemble one and demonstrate its use.
4. Measure some small objects in the laboratory using vernier calipers and a micrometer. Compare readings.

5. Find the mass of a single sheet of typewriter paper by finding the mass of 100 sheets and then dividing that value by 100.

H. References:

1. Dull, Metcalfe, Williams, *Modern Physics*, 1962 and 1965 Ed., Rinehart and Winston, Inc., New York.
2. Dull, Metcalfe and Williams, *Laboratory Experiments In Physics*, 1965, Holt, Rinehart and Winston, Inc., New York
3. Hill and Stollberg, *Physics--Fundamentals and Frontiers*, Houghton Mifflin Company, 1965, Atlanta, Georgia.
4. Lehrman, *Scientific Experiments in Physics*, Holt, Rinehart and Winston, Inc., New York.
5. Lehrman and Swartz, *Foundations of Physics*, Holt, Rinehart, Winston Inc., New York.
6. Lehrman and Swartz, *Laboratory Experiments for Foundations of Physics*, Holt, Rinehart and Winston Inc., New York.
7. Michels, Walter C., and Patterson, A. L., *Elements of Modern Physics*, Van Nostrand, 1951, New York.
8. Physical Science Study Comm., *Physics*, 2nd Ed. 1965, Heath and Co., Boston, Massachusetts.
9. Physical Science Study Comm., *Physics Laboratory Guide*, 1965, Heath and Co., Boston, Massachusetts.
10. Strollberg &Hill, *Fundamentals and Frontiers*, 1965 Ed., Houghton Mifflin Co., Boston, Massachusetts.
11. Weisskopk, Victor F., *Knowledge and Wonder*, Doubleday Anchor, 1963, Science Study Series, New York.

I. Films (available at film library):

  1. Measurement (PSSC Physics film)
  2. Short Time Intervals (PSSC Physics film)
  3. Long Time Intervals (PSSC Physics film)
  4. Time and Clocks (PSSC Physics film)
  5. Measuring Long Distances (PSSC Physics film)
  6. Straight Line Kinematics (PSSC Physics film)
  7. Vector Kinematics (PSSC Physics film)
  8. Change of Scale (PSSC Physics film)
  9. Frames of Reference (PSSC Physics film)
  10. Conservation of Energy (PSSC Physics film)
  11. Inertia (PSSC Physics film)
  12. Inertia Mass (PSSC Physics film)
  13. Encyclopedia Britannica Series--Dr. White.
  14. Matter and Energy--11 min. B/W
  15. Energy and Its Transformation--11 min. B/W

II. Force and Motion

  A. Problem: What causes objects to move?

  B. Objectives:

    1. Developing an understanding of the composition and resolution of forces.
    2. Evolving skill in the construction of force diagrams in the solution of vector problems--graphically and mathematically.
    3. Developing a wider understanding of Newton's laws of motion and their application.
    4. Developing a wider understanding of how energy is transferred and transformed through the use of machines.

5. Gaining a more thorough understanding of the following concepts of work, power, mechanical advantage, and efficiency.
6. Amplifying the following concepts: rotary motion, circular motion, simple harmonic motion, torque, coefficient of friction.
7. Gaining an understanding of centripetal force, centrifugal reaction, speed, velocity, acceleration, laws of the pendulum, and gravitation.

C. Principles:

1. Motion is controlled or changed by means of forces.
2. Quantities such as displacements are called vectors.
3. Forces that cancel out each other's effect are in equilibrium.
4. The rate of change in a particular direction is known as velocity.
5. The center of gravity of an object is the point at which it is balanced.
6. A continuing change of place or position is known as motion.
7. The rate of change of velocity is called acceleration.
8. An object will not change its state by itself.
9. An outside force will cause an object to speed up or slow down.
10. Every object in the universe attracts every other object in the universe.
11. For every action there is an equal and opposite reaction.
12. Motion may be in a straight line; along a curved path; or about an axis.
13. When motion is regular over the same path, it is periodic.

14. Work is done when a force acts on matter and changes its motion.
15. Power is the rate of doing work.
16. There are two kinds of energy - that in motion and that stored.
17. A device which changes or transmits energy is a machine.
18. Moving objects are hindered by friction.
19. Acceleration is greater when the force is greater and the mass is less.
20. The resultant of two or more forces is a substitute for those forces.
21. A force may be separated into two component forces.

D. Topics:

1. Force vectors
2. Composition of forces
3. Resolution of forces
4. Parallel forces
    a. Moment of a force (torque)
    b. Equilibrium with parallel forces
5. Center of gravity
    a. Stable Equilibrium
    b. Unstable equilibrium
    c. Neutral equilibrium
6. Friction
    a. Coefficient of friction
    b. Increasing and reducing friction

7. Motion
    a. Velocity
    b. Speed
8. Linear motion
    a. Uniformly accelerated motion
    b. Uniformly retarded motion
    c. Freely falling bodies
    d. Path of a projectile
9. Newton's three laws of motion
    a. Newton's law of inertia
    b. Newton's law of acceleration
    c. Newton's law of interaction
        (1) Impulse and momentum
        (2) Conservation of momentum
10. Universal gravitation
11. Circular motion
    a. Centripetal acceleration and force
    b. Centrifulga acceleration and force
12. Rotary motion
    a. Uniform rotary motion
    b. Variable rotary motion
    c. Angular velocity
    d. Precession
    e. The Gyroscope
13. Periodic motion
    a. Relationship between circular motion and simple harmonic motion

b. The pendulum and its period

14. Units of work

15. Units of power

16. Energy

    a. Kinetic

    b. Potential

    c. Measurement of energy

17. Machines

    a. Uses of machines

    b. Efficiency of machines

    c. Classes of machines

E. **Motivating** Activities:

1. Hang a spring balance which has a 200 gram mass suspended between two cords. Ask students if changing the angle will affect the balance reading? Demonstrate.

2. Demonstrate speed using a model electric train on a track or an auto racer set. Have students calculate average speed and velocity.

F. Experiments and/or demonstrations:

1. Experiment: Components of a force
2. Experiment: Center of gravity
3. Experiment: Rotational equilibrium
4. Experiment: Acceleration due to uniform force
5. Experiment: Centripetal force
6. Experiment: The period of a pendulum
7. Experiment: Pulleys

8. Experiment: Inclined plane
9. Experiment: Coefficient of friction
10. Experiment: Change in potential energy
11. Experiment: A head-on collision
12. Experiment: Momentum changes in an explosion
13. Experiment: A collision in two dimensions

G. Enrichment Activities:

1. Find the center of gravity of an irregular object that you find at home using nails and several pieces of string.
2. Determine the height of a flight of stairs by measuring the height of one step and multiplying this height by the number of stairs. Have someone time you as you run up the stairs. Calculate your horsepower by dividing the work by the time.
3. Find the speed with which water comes out of a jet of a garden hose. Measure the horizontal height of the hose above the ground and also the horizontal distance that the water travels before hitting the ground. Check the time from the time that the water leaves the jet until it hits the ground. Compute by using the formulas $S=\frac{1}{2}gt^2$ or $S=vt$.

H. References:

1. Bitter, Francis, Mathematical Aspects of Physics: An Introduction, Doubleday Anchor, 1963.
2. Cohen, I. Bernard, The Birth of a New Physics, Doubleday Anchor, 1960.

3. Dull, Metcalfe, Williams, Laboratory Experiments In Physics, Holt, Rinehart, and Winston, Inc.
4. Dull, Metcalfe, Williams, Modern Physics, 1965, Holt & Co.
5. Gamow, George, One, Two, Three . . . Infinity, Viking Press, 1960.
6. Lehrman, Scientific Experiments In Physics, Holt, Rinehart and Winston, Inc.
7. Little, Noel C., Physics, D. C. Heath, 1953, Boston.
8. Rogers, Eric M., Physics For The Inquiring Mind, Princeton University Press, 1960.
9. Taffell, Alexander, Physics - Its Methods And Meanings, 1965, Allyn and Bacon, Inc., Atlanta.
10. Vector - A Programmed Text for Introductory Physics, Appleton-Century-Crofts, 1962: Basic Systems.
11. PSSC, Physics Laboratory Guide, D. C. Heath Co.

I. Films (available at film library)
   1. Forces (PSSC physics film)
   2. Periodic Motion (PSSC physics film)
   3. Collisions of Hard Spheres (PSSC physics film)
   4. Energy and Work (PSSC physics film)
   5. Universal Gravitation (PSSC physics film)
   6. Elliptic Orbits (PSSC physics film)
   7. Encyclopedia Brittanica Series - Dr. Harvey White
   8. Galileo's Laws of Falling Bodies - 6 min. b/w
   9. Energy and Work - 11 min. color
   10. Simple Machines - 11 min. b/w
   11. Laws of Motion - 12 min. b/w

J. Filmstrips (to be added later)

K. Free and Inexpensive Materials

  1. The Gyroscope Through The Ages, 35 pages, free, undated. Sperry Gyroscope Co., Inc., Great Neck, N. Y. The story of the gyroscope.
  2. Space Information. National Aeronautics and Space Administration, Washington, D. C. 20546

III. Structure of Matter

A. Problem: What is the nature of matter?

B. Objectives

  1. Developing an understanding of the nature of the atom and its sub-atomic particles.
  2. Developing an appreciation of the methods and applications of nuclear research.
  3. Familiarizing students with the basic assumptions of the kinetic theory and its application.
  4. Gaining skill in the solution of problems involving atomic energy transformations and in writing nuclear reactions.

C. Principles and Concepts

  1. All radioactive elements have certain common properties.
  2. Radiations from the nuclei of radioactive elements consist of alpha particles, beta particles, and gamma rays.
  3. Stable atoms can be made artificially radioactive by nuclear bombardment.
  4. Nuclear research has been valuable in medicine, agriculture and industry.
  5. Particles in the universe are constantly in motion.
  6. The three states of matter have many common properties.

D. Topics

1. Molecules
2. Atoms
    a. The electron
    b. The proton
    c. The neutron
    d. Other atomic particles
    e. Wave properties of atomic particles
3. Uncertainty principle
4. Modern concept of atomic structure
    a. Nuclear mass defect
    b. Electron volt
5. Mass spectrograph
6. Bonding of atoms
7. Discovery of radioactivity
8. Naturally radioactive elements
    a. Properties of radioactive elements
    b. Radiations of radioactive elements
    c. Detection of radioactivity
9. Nuclear stability of the elements
10. Types of nuclear reactions
    a. Fusion
    b. Nuclear disintegration
    c. Fission
    d. Radioactive decay
        (1) Transmutation
        (2) Half-life

11. Particle accelerators
12. Artificial radioactivity
    a. Chain reactions
    b. Fusion reactions
13. Cosmic rays
14. The kinetic theory
15. Forces acting between molecules
16. The nature of solids
    a. Properties of solids
    b. Hooke's law and elastic modulus
17. The nature of liquids
    a. Properties of liquids
    b. Pascal's principle
    c. Archimedes' principle
    d. Measuring specific gravity
18. The nature of gases
    a. Properties of gases
    b. Measurement of gases
    c. Boyle's law
    d. Atmospheric pressure
19. Fluids in motion
    a. Common properties of fluids
    b. Bernoulli's principle

E. Motivating Activities

1. If a Geiger counter is available, try to pick up the amount of background radio-active fallout present.

2. Reports on work done by various scientists who developed early concepts and experiments on the atom.

F. Experiments and/or Demonstrations

1. Experiment: Radioactivity
2. Experiment: Size of a Molecule
3. Experiment: Mass of Electron
4. Experiment: Hooke's Law
5. Experiment: Liquid Pressure
6. Experiment: Archimedes' Principle
7. Experiment: Specific Gravity
8. Experiment: Boyle's Law

G. Enrichment Activities

1. Make a simple cloud chamber from a wide-mouthed screw cap glass jar. Line the inner surface with an alcohol soaked rope or piece of felt taped down. Paint a small tack or other piece of metal with a little radioactive luminous paint. Pass a strong beam of light through the jar.
2. Observe a luminous watch or clock dial in the dark under a magnifying glass. Observe the emitted particles.

H. References

1. Dull, Metcalfe, Williams, Modern Physics, 1965, Holt, Rinehart, Winston, Inc., N. Y.
2. Dull, Metcalfe and Williams, Laboratory Experiments In Physics, Holt, Rinehart and Winston, Inc. 1965
3. Lehman and Swartz, Foundations of Physics, 1965, Holt, Rinehart, Winston, Inc., N. Y.

4. Lehrman, Scientific Experiments In Physics, Holt, Rinehard and Winston, Inc.
5. Physical Science Study Com, Physics, 2nd ed. 1965, D. C. Heath and Co., Boston
6. Romer, Alfred, The Restless Atom, Doubleday Anchor, 1960, N. Y.: Science Study Series.
7. Strollberg and Hill, Physics - Fundamentals and Frontiers, 1965, Houghton Mifflin Co., Boston

I. Films (available at film library)

1. The Rutherford Atom (PSSC film)
2. Mass of the Electron (PSSC film)
3. Behavior of Gases (PSSC film)
4. Elastic Collision and Stored Energy (PSSC film)
5. Franck-Hertz Experiment (PSSC film)
6. Matter Waves (PSSC film)
7. Photons (PSSC film)
8. Photoelectric Effect (PSSC film)
9. Millikan Experiment (PSSC film)
10. Interference of Photons (PSSC film)
11. Encyclopedia Brittanica Series - Dr. Harvey White
12. Atom Smashers - 12 min. b/w
13. Atom and The Weather - 12½ min. b/w
14. Atom In Industry - 12½ min. b/w
15. Atomic Energy - 11 min. b/w
16. Atomic Energy - 11 min. b/w
17. Carbon Fourteen - 12 min. b/w

18. Archimedes' Principle - 6 min. b/w
19. Atmospheric Pressure - 11 min. b/w
20. Evidence For Molecules and Atoms - 19 min. b/w

J. Filmstrips

1. Using Atomic Energy For Electric Power - c

K. Free and Inexpensive Material

1. Experiments With Radioactivity, National Science Teachers Association, 1201 Sixtrenth Street, N. W., Washington 6, D. C. 50¢.

IV. Heat

A. Problem: What is the relationship between heat and internal energy?

B. Objectives:

1. Understanding the difference between thermal energy and temperature.
2. Promoting skill in solution of problems dealing with temperature conversion; linear, area and volume expansion of solids; and volume expansion of liquids and gases; heat energy exchange and transfer.
3. Applying Charles' and Boyle's laws to the understanding of the behavior of gases.
4. Providing an understanding of the following concepts: vaporization, sublimation; specific heat; fusion; heat capacity, equilibrium vapor pressure, critical temperature and pressure, evaporation, distillation.
5. Acquiring an appreciation for the importance of low temperature research in studying the behavior of matter.

C. Principles and Concepts

1. Heat is a form of energy due to the motion of the molecules of a substance.
2. The temperature of a material is a measure of its ability to give up heat to, or absorb heat from, other materials.
3. Most substances expand when they are heated and contract when they are cooled.
4. At absolute zero a substance has given up all of its heat.
5. The melting point of a substance is the temperature at which solid and liquid states exist together.
6. The amount of heat in a material depends upon its temperature, weight and nature of the substance.
7. Heat engines are of various types.

D. Topics

1. The nature of heat
2. Sources of heat energy
3. Heat and temperature
4. Expansion of solids
    a. Coefficient of linear expansion
    b. Coefficient of volume expansion
5. Expansion of liquids
    a. The mercury thermometer
    b. Abnormal expansion of water
6. Expansion of gases
    a. Coefficient of expansion of gases
    b. Lowest possible temperature
    c. The Kelvin scale

7. Boyle's and Charles' laws
8. General gas law
9. Heat units
10. Heat capacity
11. Specific heat
12. Method of mixtures
13. The fusion process
    a. Heat of fusion of ice
    b. Water gives up heat as it freezes
    c. Low temperatures in the laboratory and in industry
14. Vaporization
    a. Evaporation and sublimation
    b. Equilibrium vapor pressure
    c. Measuring heat of vaporization
    d. Production of liquid air
15. Relationship between heat and work
    a. First law of thermodynamics
    b. Converting heat into work
    c. Isothermal and adiabatic processes
    d. Carnot cycle
    e. Second law of thermodynamics

16. Steam turbine
17. Gas turbine
18. Turbojet engines depend on air
19. Ramjets are simple jet engines
20. Rockets do not depend on air
21. The heat pump

E. Motivating Activities

1. Using a metal ball and ring, demonstrate the expansion of solids.
2. Report on Joule's, Davy, and Rumford's preliminary determinations of heat.
3. Bounce a rubber ball on the floor. Then drop it into a mixture of ethyl alcohol and dry ice. Try bouncing the ball again.

F. Experiments and/or demonstrations

1. Experiment: Charles' law
2. Experiment: Law of Heat Exchange
3. Experiment: Specific Heat
4. Experiment: Heat of Fusion
5. Experiment: Cooling through a Change of State
6. Experiment: Effect of Pressure on the Boiling Temperature
7. Experiment: Heat of Vaporization
8. Experiment: Latent Heats of Water

G. Enrichment Activities:

1. To show that steam does work, put a small amount of water in a length of iron pipe. Close one end with a screw cap, and the other with a rubber stopper. Hold vertically over a flame. Heat gently. The stopper will be blown out by the steam.
2. Get three containers of water, one hot, one cold, and one lukewarm. Put one hand in the hot water and the other in the cold water. After a few minutes, put both hands in

the lukewarm water. What does this indicate about the reliability of the human body as a thermometer?

H. References

1. Dull, Metcalfe, Williams, Modern Physics, 1965, Holt, Rinehart, Winston, N. Y.
2. Dull, Metcalfe, Williams, Laboratory Experiments In Physics, Holt, Rinehart and Winston, Inc.
3. Hill, and Stollberg, Laboratory Investigations For Physics - Fundamentals and Frontiers, Houghton Mifflin
4. Lehrman, Scientific Experiments In Physics, 1965, Holt, Rinehart and Winston.
5. Lehrman and Swartz, Foundations of Physics, Holt, Rinehart, and Winston, Inc., New York
6. Lehrman and Swartz, Laboratory Experiments For Foundations of Physics, Holt, Rinehart and Winston, Inc.
7. Strollbyrg and Hill, Fundamentals and Frontiers, 1965 ed., Houghton Mifflin Co., Boston
8. Taffel, Alexander, Physics - Its Methods and Meanings, 1965, Allyn and Bacon, Inc., Atlanta

I. Film (available at film library)

1. Mech. Energy and Thermal Energy (PSSC film)
2. Behavior of Gases (PSSC film)
3. Encyclopedia Brittanica Series - Dr. Harvey White
4. Gas Laws and Their Application - 13 min. b/w
5. Heat - Its Nature and Transfer - 11 min. b/w
6. Things Expand When Heated - 10 min. b/w

7. Thermodynamic - 11 min. b/w
8. The Steam Engine - 11 min. b/w
9. Jet Propulsion - 11 min. b/w

J. Filmstrips

K. Free and Inexpensive Materials

1. Advanced Experiments with Gas, 27 pages, 1954, 25¢, American Gas Association, 420 Lexington Ave., N. Y., N. Y. A group of 22 advanced classroom experiments to be performed with fuel gas.

V. Wave Motion and Sound

A. **Problem:** What are waves and how have scientists put the behavior of waves to use in the production of sound?

B. Objectives:

1. Studying the nature, properties, and characteristics of waves.
2. Gaining an understanding of the relationship of sound to other forms of energy.
3. Understanding the concepts of resonance, Doppler effect, forced vibrations, quality, pitch, frequency, harmonics, and beats.

C. Principles and Concepts:

1. A wave is a disturbance that moves through matter.
2. A material medium is necessary for the transmission of sound.
3. The speed of sound depends upon the elasticity and density of the transmitting medium.
4. Many useful sounds are above or below auditory range.

5. The properties of sound are loudness, pitch and quality.
6. When the listener and the source of sound are moving relative to each other there is variation in pitch.
7. Sounds may reinforce each other.

D. Topics:

1. Characteristics and properties of waves
2. Production and transmission of sound
3. The speed of sound
4. Properties of sound
    a. Intensity
        (1) Loudness
        (2) Measurement of intensity level
    b. Frequency
        (1) Pitch depends on frequency
        (2) Doppler effect
        (3) Fundamental
        (4) Variation in frequency in musical instruments
    c. Quality
        (1) Harmonics
        (2) Discordants
5. The ear as a receiver of sound
6. Inaudible sounds
    a. Infrasonic
    b. Ultrasonic
7. Forced vibrations

8. Resonance
    a. Resonance in tubes
    b. Sound wave interference

E. Motivating Activities

1. Make a pendulum that graphs its own wavelike motion. Hang a paper cup or small funnel with a tiny opening above a dark colored cardboard. Fill the funnel with fine sand. Start the funnel to swinging back and forth as you slowly move the cardboard at right angles to the motion of the pendulum. Note the wavelike graph formed by the sand on the cardboard.
2. Hang two pendulums of the same length from the same rod. Hang two pendulums of different lengths from another rod. Check to see if their natural frequencies are the same by starting one on each rod to swinging. If their natural frequencies are the same, the second pendulum will be swinging in unison with the first pendulum. If they are not the same, the second pendulums will not swing appreciably.
3. Illustrate types of waves by means of a long spring.
4. Ask the band instructor to do a lecture demonstration on sound and music. Some of his students could demonstrate how sounds are produced by stringed instruments; wind instruments; and by vibrating membranes.

F. Experiments and/or Demonstrations

1. Experiment: Resonance in Tubes
2. Experiment: Frequency of a Tuning Fork
3. Demonstration: Resonance in Mounted Tuning Fork

4. Experiment: The Speed of Sound
5. Experiment: Pulses and Waves in a Spring

G. Enrichment Activities
1. Determine experimentally the speed of sound in carbon dioxide.
2. Read about the use of echo location in animals.
3. If your school has an oscilloscope and tape recorder, you may record several types of sounds and show the sound patterns on the oscilloscope screen.

H. References:
1. Dull, Metcalf, Williams, Modern Physics, 1965, Rinehart and Winston, Inc., New York.
2. Griffin, Donald R., Echoes of Bats and Men, Doubleday and Co., 1959.
3. Stollberg and Hill, Physics--Fundamentals and Frontiers, 1965, Houghton Mifflin Co., Boston.

I. Films
1. Simple Waves (PSSC physics film)
2. Sound Waves in Air (PSSC film)
3. Encyclopedia Brittanica Series - Dr. H. White
4. The Nature of Sound - 16 min. b/w
5. Sound Waves and Their Sources - 11 min. b/w
6. Sound Recording and Reproduction - 11 min. b/w
7. Fundamentals of Acoustics - 11 min. b/w

J. Filmstrips
1. Sound

K. Free and inexpensive material
1. The Story of the Turbine, 12 pages, undated, free. General

Electric Co., Dept 2-119, Schenectady, N. Y. Construction and Uses of the steam turbine.

2. The Story of Combustion, 30 pages, undated, free. Chrysler Corporation, P. O. Box 1919, Detroit, Michigan. A step by step explanation of how the automobile works.
3. The Story of Power, 51 pages, 1956, color, free. General Motors Public Relations Staff, Detroit, Michigan. Power from muscles, wind, water, and combustion.
4. A to Zero of Refrigeration, 93 pages, color. General Motors, Detroit 2, Michigan. A simple story of man-made cold.

A. Problem: What is light, and how is it produced?

B. Objectives:

1. Understanding the nature and characteristics of light.
2. Appreciation of how various theories have supplies new and more complete insight into the nature of light.
3. Understanding the laws of reflection and refraction and their applications.
4. Developing the fact that white light is complex; composed of light of different wave lengths.
5. Understanding the following concepts: illumination, reflection, refraction, critical angle, index of refraction, spherical aberration, magnification, interference, diffraction, polarization, and spectra.

C. Principles and Concepts:

1. The nature of light has been explained by many theories.

2. Light may be either natural or artificial.
3. Reflection is the turning back of light waves from the boundary of a medium.
4. Refraction is the bending of light rays as they pass, obliquely, from one medium into another of different density.
5. The angle of incidence is equal to the angle of reflection.
6. The real images are formed when light rays are brought to a focus and can be projected on a screen.
7. Virtual images only appear to be formed by focusing of light rays and cannot be projected on a screen.
8. The color of light is dependent on the frequencies, or wavelengths, of the radiations which reach the eye.
9. Images are formed by lenses and mirrors

D. Topics:

1. Nature of light
    a. Corpuscular theory--Newton
    b. Wave theory--Huygens
    c. Electromagnetic theory--Maxwell and Hertz
    d. Quantum theory--Max Planck, Einstein
    e. Matter waves
    f. Pressure of light
2. Sources of light
    a. Natural
    b. Artificial
3. Luminous and illuminated objects
4. Reflection, absorption and transmission of light

5. Speed of light
    a. Roemer's determination
    b. Michelson's measurement
6. Photometry
    a. Luminous intensity
    b. Luminous flux
    c. Illumination
    d. Intensity of a light source
        (1) Bunsen photometer
        (2) Joly photometer
        (3) Spherical photometer
7. The amount of illumination
8. Regular and diffuse reflection
9. Laws of reflection
10. Images formed by plane mirrors
11. Curved mirror terminology
12. Construction of ray diagrams
13. The reflecting telescope
14. Spherical aberration
15. The mirror formula
16. The nature of refraction
17. Index of refraction
18. Laws of refraction
19. The Critical angle
20. Types of lenses
21. Ray diagrams

22. Images formed by lenses
23. Lens formulas
24. Formation of images in the eye
25. Correcting defects of the eye
26. Optical instruments
    a. Camera
    b. Magnifier
    c. Microscope
    d. Telescopes
27. Dispersion
28. Spectra
29. Interference and Diffraction
30. Polarization

E. Motivating Activities

1. Move this book toward you, with one eye closed or covered. When the book has just reached the point at which the print blurs, have someone measure the distance of the book from your eye. Repeat the experiment with the other eye. Are the two distances equal? Try this with a few people of different eyes, and record the results along with their ages.
    a. Is there limit to the ability of the eye to adjust itself for clear vision?
    b. Is this limit the same for all persons, or for the two eyes of any one persion? (p. 198, Physics, PSSC)
2. Measure the height of a flagpole by measuring the length of the shadow. Then measure the length of the shadow cast

by the meter stick. The height is found by the ratio of the flagpole's height to the length of its shadow to the ratio of the meter stick's height to the length of its shadow.

F. Experiments and/or Demonstrations

1. Experiment: Photometry
2. Experiment: Plane mirrors
3. Experiment: Curved mirrors
4. Experiment: Focal length of lens
5. Experiment: Reflection and refraction of waves
6. Experiment: Diffraction and interference of light
7. Experiment: Polarized light
8. Demonstration: Microwaves
9. Experiment: Index of Refraction

G. Enrichment Activities

1. Investigate and report on the echo-sounding devices used by ships.
2. Find the index of refraction of a liquid by comparing its real and apparent depths. Fill a battery jar with water or some liquid. Hold a ruler vertically in the liquid and note its depth. Hold another ruler parallel to the first ruler outside the jar. Slightly down both rulers vertically, raise the outside ruler until its lower end seems to be at the same level as the other. The position of the liquid surface on the outside ruler shows the apparent depth of the liquid. To calculate the index of refraction of the liquid, divide the real depth by the apparent depth.

H. References

1. Dull, Metcalfe, Williams, Modern Physics, Holt, Rinehart, and Winston, Inc., 1964.
2. Dull, Metcalfe, Williams, Laboratory Experiments In Physics, Holt, Rinehart and Winston.
3. Lehrman and Swartz, Foundations of Physics, Holt, Rinehart, and Winston.
4. Lehrman and Swartz, Laboratory Experiments for Foundations of Physics, Holt, Rinehart and Winston, Inc.
5. Physical Science Study Committee, Physics, 1965, D. C. Heath and Co., Boston.
6. Stollberg and Hill, Physics--Fundamentals and Frontiers, 1965, Houghton Mifflin Co.
7. Taffel, Alexander, Physics--Its Methods and Meanings, Allyn and Bacon, Inc., 1965, Boston.

I. Films

1. Speed of Light (PSSC film)
2. Pressure of Light (PSSC film)
3. Introduction to Optics (PSSC film)
4. Encyclopedia Brittanica Series - Dr. H. White
5. Light Waves and Their Uses - 11 min. b/w
6. Demonstrations With Light (Photo-electric Cell) - 12 min. color

J. Filmstrips

K. Free and Inexpensive Materials

1. Photographic Optics, 64 pages, 1954, free. Bausch and Lomb Optical Co., Rochester 2, N. Y.

VII. Direct Current Electricity

A. Problem: What is magnetism and electrostatics and how are they related to electricity?

B. Objectives:

1. Determining a factual basis for establishing the electrical nature of matter.
2. Gaining an understanding of potential difference, capacitance, electric field intensity, electric lines of force, electrical characteristics of conducters and insulators.
3. Presenting a basic understanding of the various devices used as sources of continuous current.
4. Understanding the heating and chemical effects of an electric circuit.
5. Understanding the link between an electric current and magnetism.

C. Principles and Concepts

1. Static electricity consists of electric charges which remain on the surface of the object.
2. Static electric charges are stored by capacitors.
3. An electric current is a flow of electrons through a conductor.
4. An electric circuit is a path through which an electric current flows.

5. If work is done as a charge moves from one point to another, these two points differ in electric potential.
6. Types of electric current sources are chemical, photoelectric, thermoeleetric, piezoelectric and electromagnetic.
7. Electric energy is converted to heat in a resistance.
8. A magnetic field exists around a wire through which an electric current is passing.

D. Topics

1. Electrification
2. Kinds of electric charge
    a. Negative and positive
    b. First law of electrostatics
3. Conductors and insulators
4. Charging by conduction and induction
5. Forces between charges
    a. Coulomb's law of electrostatic
    b. Electric fields of force
6. Potential difference
7. Distribution of charges
    a. Effect of the shape of conductors
    b. Discharging effect of points
8. Capacitance
    a. Types of capacitors
    b. Combinations of capacitors
9. Electrostatic generators
    a. Electrophorus
    b. Van de Graff generator

10. Sources of direct current
    a. Electrochemical cells
        (1) primary cell
        (2) storage cell
    b. Simple voltaic cell
        (1) Dry cell
        (2) Storage cell
        (3) Fuel cell
11. Combinations of cells
    a. Batteries formed from dry cells connected in series.
    b. Batteries formed from dry cells connected in parallel.
    c. Batteries formed from dry cells connected in series-parallel.
12. Series and Parallel circuits
    a. Ohm's law for d-c circuits
    b. Determining internal resistance
    c. Resistances in series
    d. Resistances in parallel
    e. Laws of resistance
    f. Superconductivity
    g. Semiconductors
    h. Measurement of resistance
13. Electric power
    a. Electric energy is converted to heat in a resistance
    b. Joule's law
    c. Electric heating appliances
    d. Power in an electric circuit

14. Electrolysis
    a. Electrolysis cells
    b. Electrolysis of water
    c. Electroplating metals
    d. Extracting metals by electrolysis
    e. Faraday's laws of electrolysis
15. Magnetism
16. Electromagnetism
17. Meters

E. Motivating Activities

1. On a dry day suspend a rubber balloon by a thread. Charge the balloon by rubbing it with flannel. Bring another charged body near the balloon to determine its charge. If the charged body repels the balloon, it has a like charge; if it attracts, it has an opposite charge.
2. Report on the work of Michael Faraday in electrochemistry.

F. Experiments and/or Demonstrations

1. Experiment: Static Electricity
2. Experiment: Potential Difference
3. Experiment: Electrochemical Cells
4. Experiment: Combinations of Cells-$I_n$ternal Resistance
5. Experiment: Measurement of Resistance Voltmeter-Ammeter Method
6. Experiment: Electromagnetic Induction
7. Demonstration: Electric Motors and Generators
8. Demonstration: Series Resonance

9. Experiment: Measurement of Resistance-Wheatstone Bridge Method
10. Experiment: Resistances in Series and Parallel
11. Experiment: Magnetic Field of a Current
12. Experiment: Magnetic Field Near a Long Straight Wire
13. Experiment: Measurement of a Magnetic Field in Fundamental Units

G. Enrichment Activities

1. Insert a series of materials such as paper, copper, glass, tin, iron, etc., between two charged pith balls. By observing their effects on the electrostatic force, rank them by dielectric constants.
2. Report on the production of constant potential differences by chemical action.

H. References

1. Dull, Metcalfe, Williams, Modern Physics, 1965, Holt, Rinehart, and Winston, Inc.
2. Dull, Metcalfe, Williams, Laboratory Experiments In Physics, Holt, Rinehart, and Winston.
3. Hill and Stollberg, Laboratory Investigations For Physics--Fundamental and Frontiers, Houghton Mifflin
4. Jaffee, Bernard, Men of Science In America, 1958, Simon and Schuster, N. Y.
5. Physical Science Study Committee, Physics, 1965, D. C. Heath and Co.
6. PSSC, Physics Laboratory Guide, D. C. Heath Co.
7. Stollberg and Hill, Physics-Fundamentals and Frontiers, 1965 Houghton Mifflin Co.

8. Taffel, Alexander, Physics, 1965, Allyn and Bacon

I. Film

1. Counting Electrical Chgs. in Mtn. (PSSC film)
2. Electrons in a Uniform Magnetic Field (PSSC film)
3. Electrical Potential Energy and Potential Difference (1 & 2) (PSSC film)
4. Electric Lines of Force (PSSC film)
5. Electric Fields (PSSC film)
6. Elementary charges and Transfer of Kinetic Energy (PSSC film)
7. A Magnet Laboratory (PSSC film)
8. Coulomb's Law (PSSC film)
9. Coulomb's Force Constant (PSSC film)
10. Electromagnetic Waves (PSSC film)
11. Electrons At Work - 14 min. color
12. Electrostatics - 11 min. color
13. Primary Cells - 11 min. b/w
14. Series and Parallel Circuits - 11 min. b/w
15. Encyclopedia Brittanica Physics Series - Dr. Harvey White

J. **Filmstrips**

1. Resistance
2. DC Voltmeters and Ammeters

K. Free and Inexpensive Materials

1. Electrical Fundamentals, 36 p., undated, free, Chrysler Corp., P. O. Box 1919, Detroit 31, Michigan.
2. The Inside Story of Dry Batteries, 47 pages, 1957, free, National Carbon Co., Division of Union Carbide Corp., N.Y. 17

VIII. Alternating Current Electricity

A. Problem: What are the basic principles of operation of alternating current circuits?

B. Objectives:

1. Familiarizing the student with the basic concepts of Faraday's experiments, Lenz's law and Ohm's law and their importance in generating electricity and conserving energy.
2. Gaining an appreciation of the various types of electrical machinery and some important generalizations of each type.
3. Understanding the basic principles of the operation and effectiveness of alternating current circuits.
4. Acquiring skill in the application of the concepts of mutual inductance; self-inductance, induction coil, transformer, power transmission, reactance, capacitive reactance, and impedance.

C. Principles and Concepts

1. A charge experiences a force when it moved across a magnetic field producing motor effect.
2. A conductor moving across a magnetic field generates an electromotive force. Known as motor effect.
3. Alternating currents are characterized by their frequencies.
4. A circuit which contains only resistance in the load is said to be purely resistive.
5. The amount of voltage received may be increased or decreased by a transformer.

6. Capacitors in a-c circuits are subject to constant changes in potential difference across their plates.
7. Electrons flow into and out of capacitors, but not through them.

D. Topics
1. Faraday's induction experiments
2. Factors affecting induced emf.
3. Cause of induced emf.
4. Lenz's law
5. Simple a-c generator
6. Instantoous valves of current and voltage
7. Simple d-c generators
    a. d-c generators are self-excited
    b. Ohm's law and generator circuits
8. The motor effect
9. Starting circuits for d-c motors
10. Types of a-c motors
11. Mutual inductance
12. Self inductance
13. Inductors in series and parallel
14. The induction coil
15. The transformer
    a. Step-up transformer
    b. Step-down transformer
    c. Transformer losses
    d. Power transmission

16. Effective valves of an alternating current
17. a-c meters or instruments
18. Inductance in an a-c circuit
19. Impedance
20. Capacitance in an a-c circuit
21. Resistance, inductance, and capacity in series
22. Resistance, inductance, and capacity in parallel
23. Series resonance
24. Selectivity
25. Parallel resonance
26. Coupled circuits
27. Filter circuits

E. Motivating Activities

1. Have students make a simple working model of an electric motor.
2. Demonstrate Faraday's induction experiments with a horseshoe magnet, insulated wire and a galvanometer.

F. Experiments and/or demonstrations

1. Experiment: Series and Parallel Wiring
2. Experiment: Electromagnetic Induction
3. Demonstration: Electric Generator
4. Demonstration: Electric Motor
5. Demonstration: Efficiency of an Electric Motor
6. Demonstration: Capacitance in a-c Circuits
7. Demonstration: Inductance in a-c Circuits
8. Demonstration: Series Resonance

G. Enrichment Activities

1. Use a small train or doorbell transformer to measure the power consumed in the primary circuit, when the secondary circuit is closed. Compare this with the power consumed when it is used to run a train or ring a doorbell. Is it poor economy to hook up a doorbell across a 120 volt a-c house electric system 24 hours a day?
2. Determine experimentally the relationship between the numbyr of turns of a coil and its inductance.
3. Obtain an old motor. Take it apart and explain the principle and function of each part.

H. References

1. Dull, Metcalfe and Williams, Modern Physics, Holt and Co.
2. Dull, Metcalfe and Williams, Laboratory Experiments In Physics, Holt and Co.
3. Hill, Stollberg, Laboratory Investigations for Physics - Fundamentals and Frontiers, Houghton Mifflin Co.
4. Lehrman and Swartz, Foundations of Physics, Holt, Rinehart, and Winston, Inc.
5. Lehrman & Swartz, Laboratory Experiments for Foundations of Physics.
6. Physical Science Study Comm., Physics, 2nd Ed., D. C. Heath and Co.
7. PSSC, Physics Laboratory Guide, D. C. Heath Co.

I. Film

1. Electromagnetic Waves (PSSC film)

   2. E M F (PSSC film)
   3. Encyclopedia Brittanica Physics Series - Dr. H. White

- J. Filmstrips
   1. How AC and DC Motors Work
   2. Motors
   3. Transformers
   4. AC and DC Generators
   5. AC Voltmeters and Ammeters
   6. Electricity at Work
   7. Elements of Electrical Circuits - color

- K. Free and Inexpensive Materials
   1. Alternating Current Simply Explained, Timmerman, A.H., 16 pages, free, Wagoner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
   2. Network of Power, #3, 16 pages, comic booklet, free. General Electric Co., Dept. 2-119, Schenectady, N. Y.

IX. Electronics

- A. Problem: How has communication been improved by electronics?
- B. Objectives
   1. Gaining an appreciation of the important uses of vacuum tubes in communication facilities, in computers and in automation.
   2. Gaining an appreciation of the basic principles involved in the operation of radar.

3. Familiarizing students with basic concepts of television, radio, and hi-fidelity transmission and reception.
4. Developing an understanding of basic concepts involved in the operation of diodes, triodes, tetrodes, pentodes, cathode ray tubes, semiconductors and transistors.

C. Principles and Concepts

1. A signal is a pattern of energy changes.
2. Vibrating electric charge produces simultaneously vibrating electric and magnetic fields.
3. High vacuum tubes are classed as diodes, triodes, tetrodes, and pentodes depending on the number of electrodes present.
4. In high vacuum tubes, the conducting particles are electrons produced by the escape of electrons from a hot surface.
5. Gas discharge tubes operate at very low pressure.
6. The strength of a signal may be increased by use of an amplifier.
7. A beam of electrons is deflected across a cathode ray tube screen, in response to very weak signals, causing a television picture and radar detection.

D. Topics

1. Importance of vacuum tubes
    a. Functions
    b. Classification
2. Electric current is a gas
3. Thermionic emission
4. Diodes

5. Triodes
6. Tetrodes
7. Pentrodes
8. Transistors
9. P and N type semiconductors
10. Vacuum tubes can amplify electric signals
11. Oscillator circuits
12. Cathode ray oscilloscopes
13. Radio communication
14. Amplitude and frequency modulation
15. Television
16. Radar

E. Motivating Activities

1. If an oscilloscope is available, connect a radio to it and observe the wave patterns.
2. Closely examine a small section of a picture on a television receiver. Determine if each line varies in intensity from one side of the screen to the other. Determine if the lines also appear to vary in width.

F. Experiments and/or demonstrations

1. Demonstration - Voltage Amplification
2. Demonstration - Vacuum Tube Rectifier
3. Demonstration - Three-Electrode Vacuum Tube
4. Demonstration - The Oscilloscope
5. Demonstration - Operation of a Diode

G. Enrichment Activities

1. Build an amplifier from a schematic diagram. Experiment with methods in which you can modify the design and report on your results.
2. Visit an electronic shop and get further explanation of the operation and application of electronic devices.
3. Build a radio receiver. Check one of the many books on radio and electronics in the book stores.

H. References

1. Dull, Metcalfe, Williams, Modern Physics, 1964, Holt, Rinehart, and Winston, Inc.
2. Dull, Metcalfe, Williams, Laboratory Experiments In Physics, Holt, Rinehart, and Winston, Inc.
3. Lehrman, Scientific Experiments In Physics, Holt, Rinehart, & Winston, Inc.
4. Lehrman and Swartz, Laboratory Experiments for Foundations of Physics, 1965, Holt, Rinehart, and Winston, Inc.
5. Hill and Strollberg, Laboratory Investigations for Physics - Fundamentals and Frontiers, 1965, Houghton Mifflin Co.
6. Physical Science Study Committee, Physics, 2nd Ed., 1965, D. C. Heath Co.
7. Strollberg, R. and Hill, F., Physics - Fundamentals and Frontiers, 1965, Houghton Mifflin, Inc.
8. PSSC, Physics Laboratory Guide, D. C. Heath.

I. Film

1. Encyclopedia Brittanica Series - Dr. H. White

J. Filmstrips

K. Free and Inexpensive Materials

1. Adventures in Electronics, No. 7, 16 pages, comic booklet, free, General Electric Co., Dept. 2-119, Schenectady, N. Y.
2. Radio Builder's Handbook (3K-750), 41 pages, (1958), 25¢ each, and Radio Circuit Handbook (37K-753) 35 pages, (1957), 25¢ each, Allied Radio Corp., 100 N. Western Ave., Chicago 80, Ill.

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1. Bitter, Francis, Mathematical Aspects of Physics: An Introduction, Doubleday Anchor, 1963. New York
2. Cohen, I. Bernard, The Birth of a New Physics, Doubleday Anchor, New York
3. Dull, Metcalfe and Williams, Modern Physics, Holt, Rinehart and Winston, 1965, New York
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5. Dull, Metcalfe, and Williams, Laboratory Experiments In Physics, Holt, Rinehart and Winston, 1965. New York
6. Gamon, George, One, Two, Three . . . Infinity, Viking Press, 1960. New York
7. Griffin, Donald R., Echoes of Bats and Men, Doubleday and Co., 1959, New York
8. Hill and Strollberg, Laboratory Investigations For Physics - Fundamentals and Frontiers, Houghton Mifflin Co., 1965, Boston
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13. Little, Noel C., Physics, D. C. Heath, 1953, Boston

14. Michels, Walter C., and Patterson, A. L., Elements of Modern Physics, D. Van Nostrand, 1951, Princeton, New Jersey

15. Physical Science Study Committee, Physics, 2nd Ed. Heath and Co., 1965, Boston

16. Physical Science Study Committee, Physics Laboratory Guide, D. C. Heath Co., Boston

17. Rogers, Eric M., Physics for the Inquiring Mind. Princeton University Press, 1960, Princeton, New Jersey.

18. Stollberg and Hill, Physics - Fundamentals and Frontiers, Houghton Mifflin Co., 1965, Boston

19. Taffel, Alexander, Physics, Allyn and Bacon, 1965, Atlanta.

20. Vector - A Programmed Text for Introductory Physics - Appleton - Century - Crofts, 1962.

21. Weisskopk, Vicor F., Knowledge and Wonder, Doubleday Anchor, 1963, New York: Science Study Series.

RECOMMENDATIONS AND COMMENTS

A. Other supplementary books which should be in the physics classroom or library.

1. Hodgman, Charles D., et al., Handbook of Chemistry and Physics, Chemical Rubber Publishing Co., 1965, Cleveland, Ohio.
2. Steinberg, William B., et al., Electricity and Electronics, American Technical Society. 1957, Chicago.

B. New physics textbooks

1. Recently adopted physics textbooks.
    a. PSSC, Physics, Second Edition 1965: This revision developed as a result of comments and criticism of both teachers and students using this approach to physics. As a result there

has been an improvement of the quality and clarity of presentation of theory and laboratory experiences.

b. PSSC, Physics, Laboratory Guide. 1965. The laboratory experiences have been strengthened by the addition of new experiments in areas where there is a greater need.

c. Lehrman and Swartz, Foundations of Physics. 1965
This book attempts to present physics as a field of inquiry and not a fixed body of knowledge. Yet much of the material maintains the traditional approach.

d. Lehrman, and Swartz, Laboratory Experiments for Foundations of Physics, 1965.
This manual combines both the traditional approach to laboratory experiences and the open-ended approach. Some of the PSSC equipment is used in the experiments.

e. Stollberg and Hill, Physics - Fundamentals and Frontiers, 1965.
Scientific concepts are written and explained in simple language. These develop from simple observations to logical paths of thought.

f. Hill and Stollberg, Laboratory Investigations for Physics Fundamentals and Frontiers.
This manual is designed to help the student in making careful observations and drawing conclusions from his observations.

2. New books not yet state adopted.

a. Dull, Metcalfe, and Williams, Modern Physics, 1965.
Much of the new in physics has replaced some of the introductory material which students now get in earlier science courses. A good text for the general approach.

b. Dull, Metcalfe and Williams, Laboratory Experiments In Physics. 1965.

This manual gives the standard approach to laboratory work.

c. Lehrman, R., Scientific Experiments (a part of the Modern Physics Program by Holt and Co.)

This manual contains 68 open-ended experiments that follow the organization of the text (Modern Physics 1965, Holt and Co.). A "must" for a refreshing physics laboratory.